STIC Search Report
EIC 3700

USPTO

STIC Database Tracking Number: 100831

TO: Tom Barrett
Location: CP2 2D09
Art Unit: 3738

Case Serial Number: 09/997159

From: Jeanne Horrigan
Location: EIC 3700
CP2-2C08
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Search Notes

Attached are the search results for the computer model/simulation for a patient's eye and/or eye surgery, including author and prior art searches in foreign and international patent databases and prior art searches in medical and general sci/tech non-patent literature databases.

Generally I tag the items that seem most relevant to me. However, in this case, where almost all of the references for which I pulled abstracts looked relevant to me, I decided to tag only the oldest reference I found in the non-patent literature.

Also attached is a search feedback form. Completion of the form is voluntary. Your completing this form would help us improve our search services.

I hope the attached information is useful. Please feel free to contact me (phone 305-5934 or email jeanne.horrigan@uspto.gov) if you have any questions or need additional searching on this application.

JH

sira
Search and Information Resources Administration

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File 155:MEDLINE(R) 1966-2003/Aug W2
File   5:Biosis Previews(R) 1969-2003/Aug W1
File  73:EMBASE 1974-2003/Aug W1
File  34:SciSearch(R) Cited Ref Sci 1990-2003/Aug W1
File 434:SciSearch(R) Cited Ref Sci 1974-1989/Dec
File 144:Pascal 1973-2003/Aug W1
File   2:INSPEC 1969-2003/Aug W1
File   6:NTIS 1964-2003/Aug W2
File   8:Ei Compendex(R) 1970-2003/Aug W1
File  94:JICST-EPlus 1985-2003/Aug W1
File  95:TEME-Technology & Management 1989-2003/Jul W4
File  99:Wilson Appl. Sci & Tech Abs 1983-2003/Jun
File  65:Inside Conferences 1993-2003/Aug W2
File  35:Dissertation Abs Online 1861-2003/Jul
Set     Items    Description
S1   12081027    SIMULAT? OR MODEL????
S2    4106155    COMPUTER OR COMPUTERI?ED
S3    1239003    DIGITAL OR DIGITI?ED
S4    1042705    SOFTWARE
S5    1218492    EYE OR EYES OR CORNEA? OR OPHTHALMOLOG?
S6    5777271    SURGERY OR SURGERIES OR SURGICAL
S7    1131396    S2(S)S1
S8     290630    S3(S)S1
S9     187416    S4(S)S1
S10     19498    S1(5N)S5
S11      2290    S7:S9 AND S10
S12       316    S11 AND S6
S13    829938    S2()S1
S14    163014    S3()S1
S15     19484    S1()S4
S16       171    S12 AND S13:S15
S17     93764    S5(3N)S6
S18       147    S13:S15 AND S17
S19        33    S18/2001 OR S18/2002 OR S18/2003
S20       114    S18 NOT S19
S21        90    RD (unique items)
S22        75    S21 AND S6/DE
S23        74    S21 AND S5/DE
S24        69    S22 AND S23
S25    788321    S13:S15/DE,TI
S26        65    S24 AND S25
S27         7    S13:S15(S)S17 AND S26
S28         7    Sort S27/ALL/PY,D
S29        58    S26 NOT S27
S30        58    Sort S29/ALL/PY,D
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28/6/1 (Item 1 from file: 8)
05617277
Title: Performance analysis of dynamic location updation strategies for mobile users
Conference Title: 20th International Conference on Distributed Computing Systems (ICDCS 2000)
Publication Year: 2000

28/6/2 (Item 2 from file: 99)
2054258 H.W. WILSON RECORD NUMBER: BAST98060083

The eyes have it
19980800

28/6/4 (Item 4 from file: 2)
4696786 INSPEC Abstract Number: C9408-7330-010
Title: Socially correct virtual reality: surgical simulation
Publication Date: July-Aug. 1994

28/7,K/3 (Item 3 from file: 155)
DIALOG(R)File 155:MEDLINE(R)

08510760 95199036 PMID: 7891993
Computer - simulated eye surgery . **A novel teaching method for residents and practitioners.**
Sinclair M J; Peifer J W; Haleblian R; Luxenberg M N; Green K; Hull D S
Bioengineering Research Center, Georgia Institute of Technology, Atlanta.
Ophthalmology (UNITED STATES) Mar 1995, 102 (3) p517-21, ISSN 0161-6420 Journal Code: 7802443
Document type: Journal Article
Languages: ENGLISH
Main Citation Owner: NLM
Record type: Completed
PURPOSE: To describe an **eye surgery** simulator that uses a computerized graphic display to allow ophthalmic surgeons of all experience levels to enhance their **surgical** skills. METHODS: The **eye surgery** simulation environment consists of a high-speed computer graphics workstation, a stereo operating system, a wrist rest, and a position tracking stylus connected to force feedback motors. The surgeon views computer-generated images of the **eye** and **surgical** instruments through the stereo operating system and controls the position and orientation of the chosen surgical instrument by moving the stylus. During the simulated instrument-tissue interactions, three feedback motors generate component force feedback along three orthogonal axes connected by thin rigid bars to the tip of the stylus. RESULTS: The current proof-of-concept system provides a method for rapid learning experiences in a living eye simulation. Procedures can be recorded for playback and analysis, as well as for examination of techniques from different viewpoints (e.g., from inside the **eye**). Four simulated **surgical** instruments are available for use (scalpel, forceps, scissors, and phacoemulsifier). CONCLUSION: **Eye surgery** simulation offers both beginning and experienced ophthalmic surgeons an opportunity to learn new techniques and skills and achieve a satisfactory level of proficiency before use of that procedure in the operating room. When fully developed, this system should shorten the learning curve for new surgeons (i.e., residents) and offer an opportunity for practice before doing a difficult case or development of new techniques by experienced surgeons. The goal of replacement of current standard training methods for surgeons awaits further refinement and adjustment of the model.
Record Date Created: 19950417
Record Date Completed: 19950417
Descriptors: **Computer Simulation** ; * **Eye** Diseases-- **surgery** --SU; *Models, Anatomic; * **Ophthalmology** --education--ED; *Teaching--methods--MT

28/7,K/5 (Item 5 from file: 155)
DIALOG(R)File 155:MEDLINE(R)

07410240 92273537 PMID: 1591212
Numerical modeling of radial, astigmatic, and hexagonal keratotomy.
Pinsky P M; Datye D V
Department of Civil Engineering, Stanford University, CA 94305-4020.
Refractive & corneal surgery (UNITED STATES) Mar-Apr 1992, 8 (2) p164-72, ISSN 1042-962X Journal Code: 8908429
Document type: Journal Article
Languages: ENGLISH
Main Citation Owner: NLM
Record type: Completed
BACKGROUND: A mechanical model of the human cornea is proposed and employed in a finite element formulation for simulating the effects of keratotomy on the cornea. METHODS: The formulation assumes that the structural behavior of the cornea is governed by the properties of the stroma which is modeled as a thick membrane. The tensile forces in the cornea are resisted by the collagen fibrils embedded in the ground substance of the stromal lamellae. When the stromal lamellae are cut, as in keratotomy, it is assumed that they no longer carry any tensile forces, and the forces in the cornea are then resisted only by the remaining uncut lamellae. A constitutive model, which represents the anisotropy and inhomogeneity in the membrane rigidity induced by the incisions, has been employed in a geometrically nonlinear finite element membrane formulation for small strains with moderate rotations. This preliminary model is restricted to linear material behavior with no time dependency. RESULTS: A number of numerical examples are presented to illustrate the effectiveness of the proposed constitutive model and the finite element formulation for computing the immediate postoperative shift in corneal power resulting from radial, astigmatic, and hexagonal keratotomy. Surgical changes computed using the proposed model compare well with surgical corrections predicted by expert surgeons. CONCLUSIONS: The proposed computational model of the cornea and the effects of surgical procedures on it is based on a number of important simplifying assumptions regarding the mechanical properties and structure of the corneal tissue at the ultrastructure level. The encouraging results found with present model suggest that further development and refinement will be useful.
Record Date Created: 19920702
Record Date Completed: 19920702
Descriptors: Astigmatism-- **surgery** --SU; * **Computer Simulation** ; * **Cornea** --physiology--PH; *Keratotomy, Radial; Adult; Astigmatism --physiopathology--PP; **Corneal** Stroma--physiology--PH; Elasticity; Intraocular Pressure--physiology--PH; Models, Biological; Wound Healing --physiology--PH

28/7,K/6 (Item 6 from file: 155)
DIALOG(R)File 155:MEDLINE(R)

07410239 92273536 PMID: 1591211
Computer simulation **of arcuate keratotomy for astigmatism.**
Hanna K D; Jouve F E; Waring G O; Ciarlet P G
Department of Ophthalmology, Emory University, Atlanta, GA 30322.
Refractive & corneal surgery (UNITED STATES) Mar-Apr 1992, 8 (2) p152-63, ISSN 1042-962X Journal Code: 8908429
Document type: Journal Article
Languages: ENGLISH
Main Citation Owner: NLM
Record type: Completed

BACKGROUND: The development of refractive **corneal surgery** involves numerous attempts to isolate the effect of individual factors on surgical outcome. **Computer simulation** of refractive keratotomy allows the surgeon to alter variables of the technique and to isolate the effect of specific factors independent of other factors, something that cannot easily be done in any of the currently available experimental models. METHODS: We used the finite element numerical method to construct a mathematical model of the eye. The model analyzed stress-strain relationships in the normal corneoscleral shell and after astigmatic surgery. The model made the following assumptions: an axisymmetric eye, an idealized aspheric anterior corneal surface, transversal isotropy of the cornea, nonlinear strain tensor for large displacements, and near incompressibility of the corneoscleral shell. The eye was assumed to be fixed at the level of the optic nerve. The model described the acute elastic response of the **eye** to **corneal surgery** . RESULTS: We analyzed the effect of paired transverse arcuate corneal incisions for the correction of astigmatism. We evaluated the following incision variables and their effect on change in curvature of the incised and unincised meridians: length (longer, more steepening of unincised meridian), distance from the center of the cornea (farther, less flattening of incised meridian), depth (deeper, more effect), and the initial amount of astigmatism (small effect). CONCLUSIONS: Our finite element **computer model** gives reasonably accurate information about the relative effects of different surgical variables, and demonstrates the feasibility of using nonlinear, anisotropic assumptions in the construction of such a **computer model** . Comparison of these computer-generated results to clinically achieved results may help refine the **computer model** .

Record Date Created: 19920702
Record Date Completed: 19920702
Descriptors: Astigmatism-- **surgery** --SU; * **Computer Simulation** ; *Keratotomy, Radial; Biomechanics; Collagen--physiology--PH; **Cornea** --physiology--PH; **Corneal** Stroma--physiology--PH; Elasticity; Intraocular Pressure--physiology--PH; Mathematics; Rats; Sclera--physiology--PH

28/7,K/7 (Item 7 from file: 155)
DIALOG(R)File 155:MEDLINE(R)

06957323 91197801 PMID: 2488791

A mechanical model of the cornea: the effects of physiological and surgical factors on radial keratotomy surgery.

Vito R P; Shin T J; McCarey B E
School of Mechanical Engineering, Georgia Institute of Technology, Atlanta 30332.
Refractive & corneal surgery (UNITED STATES) Mar-Apr 1989, 5 (2) p82-8, ISSN 1042-962X Journal Code: 8908429
Document type: Journal Article
Languages: ENGLISH
Main Citation Owner: NLM
Record type: Completed

A finite element-based **computer simulation** of radial keratotomy surgery was conducted to study, in particular, curvature changes of the central clear zone in human cornea under various physiological and **surgical** conditions. **Corneal** tissue was assumed to behave as a nearly incompressible, linear elastic, homogeneous, isotropic material undergoing small deformation. The Young's modulus was determined by using the model to predict the surgical outcome of a representative patient. The results of

the simulation are in qualitative agreement with clinical experience indicating the potential of finite element modeling as an aid to the surgeon in evaluating variables.
Record Date Created: 19910523
Record Date Completed: 19910523
Descriptors: **Computer Simulation** ; * **Cornea** --physiology--PH; *Keratotomy, Radial; Biomechanics; **Cornea** -- **surgery** --SU; Elasticity; Intraocular Pressure; Keratotomy, Radial--methods--MT; Prognosis; Refraction, Ocular

30/6/2 (Item 2 from file: 155)
09096860 20394680 PMID: 10938767
Initial in vivo results of a hybrid retinal photocoagulation system.
Jan 2000

30/6/3 (Item 3 from file: 8)
05752420
Title: Orbscan modeling of the post-PRK corneal thickness profile
Conference Title: American Academic of Optometry Annual Meeting Scientific Program
Publication Year: 2000

30/6/4 (Item 4 from file: 8)
05629568
Title: How detrimental is eye movement during photorefractive keratectomy to the patient's post-operative vision?
Conference Title: Ophthalmic Technologies X
Publication Year: 2000

30/6/5 (Item 5 from file: 94)
04831463 JICST ACCESSION NUMBER: 01A0200372 FILE SEGMENT: JICST-E
Hyperopic Refractive Shift of Piggybacking Posterior Chamber Intraocular Lens Implantation and Its Refractive Computer Simulation . , 2000

30/6/6 (Item 6 from file: 144)
13920261 PASCAL No.: 99-0101978
Computer modeling **of visual impairment caused by intraocular lens misalignment**
1999

30/6/7 (Item 7 from file: 155)
11986269 99431412 PMID: 10504087
From earth to the moon.
Sep-Oct 1999

30/6/8 (Item 8 from file: 155)
08881580 20167794 PMID: 10703149
Brown's syndrome: diagnosis and management.
1999

30/6/9 (Item 9 from file: 73)
07867249 EMBASE No: 1999347848
Penetrating injury of the eye
1999

30/6/12 (Item 12 from file: 144)
13702661 PASCAL No.: 98-0457357

Spot diameters for scanning photo-refractive keratectomy : A comparative study
Ophthalmic technologies VIII : San Jose CA, 24-25 January 1998
1998

30/6/16 (Item 16 from file: 8)
05321796
Title: Design of a microkeratome
Publication Year: 1998

30/6/17 (Item 17 from file: 155)
11072587 97427422 PMID: 9340930
[The intrastromal corneal ring (KeraVision Ring, ICR, ICRS). A modern method for correcting minor myopia]
1997

30/6/18 (Item 18 from file: 155)
10788328 97138609 PMID: 8985635
Computer simulation **of centration effects on corneal-topography analysis of excimer laser photorefractive keratectomy ablations.**
Jan 1997

30/6/20 (Item 20 from file: 8)
04798415
Title: Redistribution of inplane stresses with changes in stromal hydration in the human cornea
Conference Title: Proceedings of the 1997 Bioengineering Conference
Publication Year: 1997

30/6/21 (Item 21 from file: 94)
03437988 JICST ACCESSION NUMBER: 97A0954606 FILE SEGMENT: JICST-E
Computer Aided Surgery and LASER., 1997

30/6/22 (Item 22 from file: 155)
10475706 96285125 PMID: 8753983
[Decrease of retinal image contrast after photorefractive keratectomy, improvement within the scope of surface restitution]
Jun 1996

30/6/24 (Item 24 from file: 8)
04524664
Title: Mechanisms of corneal epithelial wound healing
Publication Year: 1996

30/6/25 (Item 25 from file: 155)
10255795 96057401 PMID: 7553114
An empirical model of hyperopic shift with corticosteroid modulation and refractive power prediction after photorefractive keratectomy.
May-Jun 1995

30/6/27 (Item 27 from file: 155)
10217179 96018371 PMID: 7554835
Ophthalmic microsurgical robot and associated virtual environment.
Mar 1995

30/6/30 (Item 30 from file: 8)

04209858
Title: Proceedings of the 1995 14th Southern Biomedical Engineering Conference
Conference Title: Proceedings of the 1995 14th Southern Biomedical Engineering Conference
Publication Year: 1995

30/6/32 (Item 32 from file: 95)
00885767 F95066001941
Computer simulation **of corneal curvature change caused by intrastromal ablations using a pico-second lasersystem**
1995

30/6/33 (Item 33 from file: 144)
11878901 PASCAL No.: 95-0043381
Changes in refraction induced by change in intraocular lens position
1994

30/6/36 (Item 36 from file: 94)
02257075 JICST ACCESSION NUMBER: 95A0109858 FILE SEGMENT: JICST-E
Application of Macintosh Computer to Eyelid-surgery., 1994

30/6/37 (Item 37 from file: 95)
00828679 F94110097964
Physical properties of model viscoelastic materials
1994

30/6/39 (Item 39 from file: 155)
07806156 93261692 PMID: 8493020
Holmium laser thermokeratoplasty.
May 1993

30/6/40 (Item 40 from file: 144)
10153033 PASCAL No.: 92-0358787
Computer modeling **of wound gape following radial keratotomy : Biomechanics of the cornea**
1992

30/6/41 (Item 41 from file: 144)
10148870 PASCAL No.: 92-0354624
Optical properties of diffractive, bifocal, intraocular lenses
1992

30/6/43 (Item 43 from file: 155)
07366931 92230098 PMID: 1566527
Computer model **of ultrasonic hyperthermia and ablation for ocular tumors using B-mode data.**
1992

30/6/45 (Item 45 from file: 94)
01612993 JICST ACCESSION NUMBER: 92A0529150 FILE SEGMENT: JICST-E
An analysis of vitreous tamponade effect in encircling surgery by means of finite element method., 1992

30/6/46 (Item 46 from file: 73)
04708029 EMBASE No: 1991201383

Effect of extraocular muscle surgery **on** corneal **topography**
1991

30/6/47 (Item 47 from file: 94)
01501523 JICST ACCESSION NUMBER: 91A0686528 FILE SEGMENT: JICST-E
Special issue : ophthalmology and ME.Engineering of future ophthalmology.,
1991

30/6/48 (Item 48 from file: 6)
1512289 NTIS Accession Number: DE90007623
Laser-produced plasmas in medicine
1990

30/6/49 (Item 49 from file: 144)
08877236 PASCAL No.: 90-0045113
Scanning slit delivery system
1989

30/6/51 (Item 51 from file: 155)
06256895 89272763 PMID: 2730411
Preliminary computer simulation **of the effects of radial keratotomy.**
Jun 1989

30/6/53 (Item 53 from file: 155)
05998318 89012999 PMID: 3172746
Corneal curvature change due to structural alternation by radial keratotomy.
Aug 1988

30/6/54 (Item 54 from file: 94)
00661354 JICST ACCESSION NUMBER: 88A0447904 FILE SEGMENT: JICST-E
Application of the rendering system for the clinical eye surgery . ,
1988

30/6/55 (Item 55 from file: 144)
08181824 PASCAL No.: 88-0182174
Analysis of the dosage controversy in recess-resect and Faden surgery with the Robinson computer model **of eye movements**
1987

30/6/56 (Item 56 from file: 73)
03136803 EMBASE No: 1986159380
Oxygen flux into the aberrant cornea
1986

30/6/57 (Item 57 from file: 144)
04776653 PASCAL No.: 83-0017410
Interaction of intraocular air and sulfur hexafluoride with nitrous oxide: a computer simulation
1982

30/7/1 (Item 1 from file: 155)
DIALOG(R)File 155:MEDLINE(R)

09167208 20470562 PMID: 11019883
Preoperative simulation of outcomes using adaptive optics.

Bille J F
Kirchhoff Institute of Physics, University of Heidelberg, Germany.
Journal of refractive surgery (Thorofare, N.J. - 1995) (UNITED STATES) Sep-Oct 2000, 16 (5) pS608-10, ISSN 1081-597X Journal Code: 9505927
Document type: Journal Article; Review; Review, Tutorial
Languages: ENGLISH
Main Citation Owner: NLM
Record type: Completed
Measurements of the wavefront of light reflected from the retina of the human eye can be used to determine optical aberrations of the human eye for large pupils. An instrument based on the Hartmann-Shack principle was developed. The wavefront is refracted by a microlens array and detected by a CCD camera. In first clinical studies human volunteer eyes and preoperative and postoperative refractive **surgical** patient **eyes** have been examined. An adaptive optical closed loop system has been devised for preoperative simulation of refractive outcomes of aberration free refractive surgical procedures. (2 Refs.)
Record Date Created: 20010102
Record Date Completed: 20010111

30/7/10 (Item 10 from file: 2)
DIALOG(R)File 2:INSPEC
(c) 2003 Institution of Electrical Engineers. All rts. reserv.
6628893 INSPEC Abstract Number: A2000-15-0150-004, C2000-08-7330-123
Title: EyeSi-a simulator for intra-ocular surgery
Author(s): Schill, M.A.; Wagner, C.; Hennen, M.; Bender, H.-J.; Manner,R.
Author Affiliation: Mannheim Univ., Germany
Conference Title: Medical Image Computing and Computer-Assisted Intervention - MICCAI'99. Second International Conference. Proceedings (Lecture Notes in Computer Science Vol.1679) p.1166-74
Editor(s): Taylor, C.; Colchester, A.
Publisher: Springer-Verlag, Berlin, Germany
Publication Date: 1999 Country of Publication: Germany xxi+1240 pp.
ISBN: 3 540 66503 X Material Identity Number: XX-1999-03115
Conference Title: Medical Image Computing and Computer-Assisted Intervention - MICCAI'99
Conference Date: 19-22 Sept. 1999 Conference Location: Cambridge, UK
Language: English Document Type: Conference Paper (PA)
Treatment: Practical (P)
Abstract: Presents a computer-based medical workstation for the simulation of a vitrectomy that allows the training of and rehearsal by eye surgeons. The surgeon manipulates two original instruments inside a cardanically suspended mechanical model of the eye. The instrument positions are tracked by CCD cameras and monitored by a PC which then renders the scenery using a computer graphical model of the eye and the instruments. Stereoscopic images are presented to the user by means of two small LCD displays that are mounted on the system and emulate the stereo microscope used in real operations. The simulator offers the training of intra-ocular navigation as well as first approaches to interaction with pathological tissues using mass-spring and 3D chainmail models. All operations (tracking, rendering, collision detection and tissue manipulation) are computed in real-time on a PC. (8 Refs)
Subfile: A C
Copyright 2000, IEE

30/7/11 (Item 11 from file: 8)

DIALOG(R)File 8:Ei Compendex(R)

05295240 E.I. No: EIP99064691049
Title: Simulating and optimizing of argon laser iridectomy. Influence of irradiation duration on the corneal and lens thermal injury
Author: Apiou-Sbirlea, Gabriela; L'Huillier, Jean-Pierre
Corporate Source: CER-ENSAM, Angers, Fr
Conference Title: Proceedings of the 1998 Medical Applications of Lasers in Dermatology, Cardiology, Ophthalmology, and Dentistry II
Conference Location: Stockholm, SWE Conference Date: 19980911-19980912
Sponsor: EOS; SPIE; ELA; SSL; et al.
E.I. Conference No.: 55102
Source: Proceedings of SPIE - The International Society for Optical Engineering v 3564 1999. p 101-113
Publication Year: 1999
CODEN: PSISDG ISSN: 0277-786X
Language: English
Document Type: JA; (Journal Article) Treatment: T; (Theoretical)
Journal Announcement: 9907W4
Abstract: A 3-D finite element model of the human eye is developed to study the heat transfers induced by an argon laser absorbed on the iris tissue. The main objective is to explain the appearance of complications inherent to the iridectomy such as corneal burns and lens opacities. Contraction burn preceding the iris opening by photovaporization is studied. The iris temperature threshold fixed as onset for the tissue removal is 300 degree C. For closed angle glaucoma, the thermal history on the corneal endothelium and lens due to recurrent laser shots with pulse durations of 0.5 sec, 0.05 sec and 0.04 sec are presented and discussed. Typically, an overheating of the lens and cornea endothelium by the side of the iridectomy site is observed. This phenomena is important on the cornea endothelium where the temperature increases to 70 degree C in case of two recurrent laser pulses of 0.5 sec in duration, 0.43 W in power and 0.5 sec in relaxation time. For irradiation time of 0.05 sec this overheating is much less important and the temperature on the cornea endothelium doesn't exceed 47 degree C. These computations confirm that short laser pulses decrease the amount of adverse effects and agree well with experiments reported by ophthalmologists. (Author abstract) 30 Refs.

30/7/13 (Item 13 from file: 155)
DIALOG(R)File 155:MEDLINE(R)

11377376 98258352 PMID: 10178351
Ophthalmic surgical simulator demonstrated.
Telemedicine and virtual reality (UNITED STATES) Apr 1998, 3 (4) p43, ISSN 1089-5841 Journal Code: 9617314
Document type: News
Languages: ENGLISH
Main Citation Owner: NLM
Record type: Completed
Record Date Created: 19980521
Record Date Completed: 19980521

30/7/14 (Item 14 from file: 2)
DIALOG(R)File 2:INSPEC

6195403 INSPEC Abstract Number: A1999-08-8770G-015, C1999-04-7330-348

Title: Virtual reality vitrectomy simulator
Author(s): Neumann, P.F.; Sadler, L.L.; Gieser, J.
Author Affiliation: Div. of Neuroimage Sci., Illinois Univ., Chicago, IL, USA
Conference Title: Medical Image Computing and Computer-Assisted Intervention - MICCAI'98. First International Conference. Proceedings p. 910-17
Editor(s): Wells, W.M.; Colchester, A.; Delp, S.
Publisher: Springer-Verlag, Berlin, Germany
Publication Date: 1998 Country of Publication: Germany xxii+1256 pp.
ISBN: 3 540 65136 5 Material Identity Number: XX-1998-02825
Conference Title: Medical Image Computing and Computer-Assisted Intervention - MICCAI'98. First International Conference. Proceedings
Conference Date: 11-13 Oct. 1998 Conference Location: Cambridge, MA,USA
Language: English Document Type: Conference Paper (PA)
Treatment: Practical (P)
Abstract: A virtual reality vitrectomy simulator is being developed to assist ophthalmology residents in correcting retinal detachments. To simulate this type of **surgery** , a computerized 3D **eye** model was constructed and coupled with a mass-spring system for elastic deformations. Five surgical instruments are simulated: a pick, a blade, a suction cutter, a laser and a drainage needle. The simulator is evaluated by a group of fellows and retinal surgeons with a subjective Cooper-Harper survey, which is commonly used for flight simulators. (17 Refs)
Subfile: A C
Copyright 1999, IEE

30/7/15 (Item 15 from file: 2)
DIALOG(R)File 2:INSPEC
(c) 2003 Institution of Electrical Engineers. All rts. reserv.
6195378 INSPEC Abstract Number: A1999-08-8745-038, C1999-04-7330-328
Title: Biomechanical simulation of the vitreous humor in the eye using an enhanced ChainMail algorithm
Author(s): Schill, M.A.; Gibson, S.F.F.; Bender, H.-J.; Manner, R.
Author Affiliation: Mitsubishi Electr. Res. Lab., Cambridge, MA, USA
Conference Title: Medical Image Computing and Computer-Assisted Intervention - MICCAI'98. First International Conference. Proceedings p. 679-87
Editor(s): Wells, W.M.; Colchester, A.; Delp, S.
Publisher: Springer-Verlag, Berlin, Germany
Publication Date: 1998 Country of Publication: Germany xxii+1256 pp.
ISBN: 3 540 65136 5 Material Identity Number: XX-1998-02825
Conference Title: Medical Image Computing and Computer-Assisted Intervention - MICCAI'98. First International Conference. Proceedings
Conference Date: 11-13 Oct. 1998 Conference Location: Cambridge, MA,USA
Language: English Document Type: Conference Paper (PA)
Treatment: Practical (P)
Abstract: The focus of this paper is the newly developed enhanced ChainMail algorithm that is to be used for modeling the vitreous humor in the **eye** during **surgical** simulation. The simulator incorporates both visualization and biomechanical modeling of a vitrectomy, an intraocular surgical procedure for removing the vitreous humor. The enhanced ChainMail algorithm extends the capabilities of an existing algorithm for modeling deformable tissue, 3D ChainMail, by enabling the modeling of inhomogeneous material. In this paper, we present the enhanced algorithm and demonstrate its capabilities in 2D. (7 Refs)

Subfile: A C

30/7/19 (Item 19 from file: 73)
DIALOG(R)File 73:EMBASE

07151607 EMBASE No: 1998039997
Sixty strabismus cases operated with the Computerized Strabismus Model 1.0: When does it benefit, when not?
Simonsz H.J.; Van Minderhout H.M.; Spekreijse H.
Dr. H.J. Simonsz, Dept. Ophthalmology, Dijkzigt Ziekenhuis,
Molewaterplein 40, NL 3015 GD Rotterdam Netherlands
AUTHOR EMAIL: Simonsz@compuserve.com
Strabismus (STRABISMUS) (Netherlands) 1997, 5/4 (203-214)
CODEN: SRABF ISSN: 0927-3972
DOCUMENT TYPE: Journal; Article
LANGUAGE: ENGLISH SUMMARY LANGUAGE: ENGLISH
NUMBER OF REFERENCES: 28
While, in routine strabismus surgery, empirical guidelines and experience are the best in judging which eye muscles to operate, a complex case may need a unique surgical approach, the consequences of which cannot always be envisioned in detail. We sought to improve the results of surgery in these cases by preoperative simulation of each case with the Computerized Strabismus Model 1.0 (CSM). The basis of this model was laid by David A. Robinson. It has been improved by us over the past years to the point that it can be used clinically. Improvements concerned, for example, the mechanics of the eye muscles and the anatomy of insertions and origins. The ease of operation has been improved and the algorithms have been made so much faster that a full calculation for 9 positions of gaze now takes 10 seconds on a hand-held Hewlett Packard 200LX Palmtop. From 1994 onwards, all cases to be operated in our department which were more complex than straightforward horizontal rectus muscle surgery were simulated in the model preoperatively. The predictions of the model compared well with the actual result of surgery in most cases. The model was particularly good in handling complex and unique disorders of motility. However, the model could not reliably predict the effect of strabismus surgery in cases with mechanical restrictions of motility.

30/7/23 (Item 23 from file: 73)
DIALOG(R)File 73:EMBASE

06480155 EMBASE No: 1996146892
Robinson's computerized strabismus model comes of age
Simonsz H.J.; Spekreijse H.
Molewaterplein 40,NL 3015 GD Rotterdam Netherlands
Strabismus (STRABISMUS) (Netherlands) 1996, 4/1 (25-40)
CODEN: SRABF ISSN: 0927-3972
DOCUMENT TYPE: Journal; Article
LANGUAGE: ENGLISH SUMMARY LANGUAGE: ENGLISH
In this article we review our further development of D.A. Robinson's computerized strabismus model. First, an extensive literature study has been carried out to get more accurate data on the anatomy of the average eye and the eye muscles, and about how these vary with age and with refraction. Secondly, the force-length relations that represent the mechanical characteristics of the eye muscles in the model have been determined more accurately in vivo recently, and the model was changed

accordingly. Thirdly, many parameters that were free in the original model and not derived from in vivo measurements were replaced by derivatives from in vivo measurements or made redundant. Fourthly, the ease of operation was improved greatly and the algorithms were made so much faster that a calculation for nine positions of gaze now takes ten seconds on a hand-held HP 200LX Palmtop. The predictions of the model compared well with clinical results in horizontal muscle surgery, oblique muscle surgery, forced duction tests and abducens, oculomotor or trochlear palsies. Consequently, complex strabismus surgery in our clinic is now guided by the predictions of the **computerized model** .

30/7/26 (Item 26 from file: 155)
DIALOG(R)File 155:MEDLINE(R)

10225248 96026502 PMID: 7560799
[SOPHOCLE (Ophthalmologic Simulator of Laser PHOtocoagulation): contribution to virtual reality]
SOPHOCLE (Simulateur Ophtalmologique de PHOtoCoagulation LaSer): contribution de la realite virtuelle.
Rouland J F; Dubois P; Chaillou C; Meseuree P; Karpf S; Godin S; Duquenoy F
Clinique Ophtalmologique, CHRU Hopital Huriez, Lille.
Journal francais d'ophtalmologie (FRANCE) 1995, 18 (8-9) p536-41, ISSN 0181-5512 Journal Code: 7804128
Document type: Journal Article ; English Abstract
Languages: FRENCH
Main Citation Owner: NLM
Record type: Completed
PURPOSE: This study was undertaken to teach laser retinal photocoagulation in different disorders using a "virtual .eye". Most ophthalmologists routinely use laser photocoagulator. Both indications and laser effects are well-known. However, in various diseases (diabetic retinopathy, age-related-macular degeneration, myopia...) complications rate increase or at least does not decrease. The main reasons are: - ignorance of risk factors, - misuse of the instrument. METHODS: We developed a new automated device stimulating a real laser photocoagulator. Only slit-lamp exists. The three-mirror lens, the fundus and the retinal photocoagulation impacts are "virtual". CONCLUSION: The aim of the simulator is to help practitioners to recognize various pathologies almost as in real conditions and to be familiar with different technics of photocoagulation. By using computer assisted learning, a constant evaluation determines the level and the progress of practitioners.
Record Date Created: 19951122
Record Date Completed: 19951122

30/7/28 (Item 28 from file: 155)
DIALOG(R)File 155:MEDLINE(R)

08659117 95347714 PMID: 7622151
Simulator for laser photocoagulation in ophthalmology.
Dubois P; Rouland J F; Meseure P; Karpf S; Chaillou C
CLARC-Laboratoire de Biophysique, Universite de Lille II, France.
IEEE transactions on bio-medical engineering (UNITED STATES) Jul 1995, 42 (7) p688-93, ISSN 0018-9294 Journal Code: 0012737
Document type: Journal Article
Languages: ENGLISH
Main Citation Owner: NLM

Record type: Completed

The practice of laser photocoagulation plays a major role in the ocular therapy, but the persistence of many postoperative complications denotes genuine difficulty in mastering the technique. The authors present a device which, thanks to the use of simulation, enables actual practice to be dissociated from apprenticeship. While complying with the constraints of realism with regard to habitual conditions of laser use, the device offers access to a wide variety of clinical situations. The apparatus is built around the traditional instrument. A virtual image of the fundus is produced in real time from the sensors which detect the actual gestures used. The calculations make use of textured geometrical models. Digitized color photographs are organized to form a database which reflects the diversity of pigmentations and pathologies. A software interface has been developed to facilitate the use of the device. The prototype is operated using a PC-compatible computer; it displays the images at the rate of at least seven per second on a miniature CGA screen incorporated in the slit-lamp. It is currently being validated for clinical applications. Above and beyond apprenticeship in laser photocoagulation, its potential applications extend to the entire field of ophthalmogical symptomatology and, more broadly, to the simulation of any examination conducted with the help of binocular or endoscopic optics.

Record Date Created: 19950831

Record Date Completed: 19950831

30/7/29 (Item 29 from file: 155)

DIALOG(R)File 155:MEDLINE(R)

08516234 95204511 PMID: 7896859

Aphakia correction by synthetic intracorneal implantation: a new tool for quantitative predetermination of the optical quality.

Charbonnier J B; Charmet J C; Vallet D; Dupoisot H; Martinsky M

Laboratoire P.M.M.H., URA CNRS 857, E.S.P.C.I., Paris.

Journal of biomechanics (UNITED STATES) Feb 1995, 28 (2) p167-71, ISSN 0021-9290 Journal Code: 0157375

Document type: Journal Article

Languages: ENGLISH

Main Citation Owner: NLM

Record type: Completed

To improve the a priori estimation of optical quality of synthetic intracorneal implantation, numerical calculations were performed involving the intraocular overpressure, the cleavage depth and the type of the implant. Optical correction ratios, that were determined, are in close agreement with the obtained mechanical effects.

Record Date Created: 19950427

Record Date Completed: 19950427

30/7/31 (Item 31 from file: 8)

DIALOG(R)File 8:Ei Compendex(R)

04204167 E.I. No: EIP95032633986

Title: Ophthalmic microsurgical robot and surgical simulator

Author: Hunter, Ian W.; Jones, Lynette; Doukoglou, Tilemachos; Lafontaine, Serge; Hunter, Peter J.; Sagar, Mark

Corporate Source: Massachusetts Inst. of Technology, Cambridge, MA, USA

Conference Title: Telemanipulator and Telepresence Technologies

Conference Location: Boston, MA, USA Conference Date: 19941031-19941101

Sponsor: SPIE - Int Soc for Opt Engineering, Bellingham, WA USA
E.I. Conference No.: 22143
Source: Proceedings of SPIE - The International Society for Optical Engineering v 2351 1995. Society of Photo-Optical Instrumentation Engineers, Bellingham, WA, USA. p 184-190
Publication Year: 1995
CODEN: PSISDG ISSN: 0277-786X ISBN: 0-8194-1686-X
Language: English
Document Type: CA; (Conference Article) Treatment: A; (Applications)
Journal Announcement: 9509W2

Abstract: A teleoperated microsurgical robot has been developed together with a virtual environment for microsurgery on the eye. Visual and mechanical information is relayed via bidirectional pathways between the slave and master of the microsurgical robot. The system permits surgeons to operate in one of three alternative modes: on real tissue, on physically simulated tissue in a mannequin, or on a computer based physical model contained within the ophthalmic virtual environment. In all three modalities, forces generated during tissue manipulation (i.e. resecting, probing) are fed back to the surgeon via a force reflecting interface to give the haptic sensations (i.e. ?feel') appropriate to the actions being performed. The microsurgical robot has been designed so that the master and slave systems can be in physically separate environments which permits remote surgery to be performed. The system attempts to create an immersive environment for the operator by including not only visual and haptic feedback, but also auditory, cutaneous, and, ultimately, olfactory sensations. 8 Refs.

30/7/34 (Item 34 from file: 155)
DIALOG(R)File 155:MEDLINE(R)

08181027 94246948 PMID: 8189715

A mechanical model for radial keratotomy: toward a predictive capability.

Wray W O; Best E D; Cheng L Y
Los Alamos National Laboratory, NM 87545.

Journal of biomechanical engineering (UNITED STATES) Feb 1994, 116 (1) p56-61, ISSN 0148-0731 Journal Code: 7909584
Document type: Journal Article
Languages: ENGLISH
Main Citation Owner: NLM
Record type: Completed

A detailed three-dimensional finite element model for radial keratotomy has been developed. The model includes the full load-bearing tunic of the eye and employs realistic geometry. Incisions are modeled explicitly, and material parameters are obtained from in vivo data. Calculated results obtained with the model are compared with data from two independent medical studies on radial keratotomy.

Record Date Created: 19940621
Record Date Completed: 19940621

30/7/35 (Item 35 from file: 2)
DIALOG(R)File 2:INSPEC

4784993 INSPEC Abstract Number: C9411-7330-114

Title: A virtual environment and model of the eye **for** surgical **simulation**

Author(s): Sagar, M.A.; Bullivant, D.; Mallinson, G.D.; Hunter, P.J.;

Hunter, I.W.
Author Affiliation: Aukland Univ., New Zealand
p.205-12
Publisher: ACM, New York, NY, USA
Publication Date: 1994 Country of Publication: USA 512 pp.
ISBN: 0 89791 667 0
U.S. Copyright Clearance Center Code: 0 89791 667 0/94/007/0205$01.50
Conference Title: Proceedings of 21st International SIGGRAPH Conference
Conference Sponsor: ACM
Conference Date: 24-29 July 1994 Conference Location: Orlando, FL, USA
Language: English Document Type: Conference Paper (PA)
Treatment: Practical (P)
Abstract: An anatomically detailed 3D computer graphic model of the eye and surrounding face within a virtual environment has been implemented for use in a surgical simulator. The simulator forms part of a teleoperated micro-surgical robotic system being developed for **eye surgery** . The model has been designed to both visually and mechanically simulate features of the human eye by coupling computer graphic realism with finite element analysis. This paper gives an overview of the system with emphasis on the graphical modelling techniques and a computationally efficient framework for representing anatomical details of the eye and for finite element analysis of the mechanical properties. Examples of realistic images coupled to a large deformation finite element model of the cornea are presented. These images can be rendered sufficiently fast for the virtual reality application. (15 Refs)
Subfile: C

30/7/38 (Item 38 from file: 155)
DIALOG(R)File 155:MEDLINE(R)
(c) format only 2003 The Dialog Corp. All rts. reserv.
07824400 93279945 PMID: 8505209
Optical zone diameters for photorefractive corneal surgery .
Roberts C W; Koester C J
Department of Ophthalmology, Cornell University Medical College, New York, NY 10021.
Investigative ophthalmology & visual science (UNITED STATES) Jun 1993, 34 (7) p2275-81, ISSN 0146-0404 Journal Code: 7703701
Document type: Journal Article
Languages: ENGLISH
Main Citation Owner: NLM
Record type: Completed
PURPOSE. To examine the physiological optics of photorefractive **corneal surgery** and to study the effect on glare production of the optical zone diameter. METHODS. An optical analysis computer program was used to generate rays that define the edge of the optical zone for any given pupil size and glare-free field. RESULTS. The optical zone diameter must be based on the postoperative corneal curvature because the determines magnification of the pupil. The minimal optical zone diameter of uniform optical power was determined both for myopic and hyperopic surgery and for two values of anterior chamber depth. CONCLUSIONS. Optical zone diameters must be at least as large as the entrance pupil diameter to preclude glare at the fovea, and larger than the entrance pupil to preclude parafoveal glare.
Record Date Created: 19930707
Record Date Completed: 19930707

30/7/42 (Item 42 from file: 155)

DIALOG(R)File 155:MEDLINE(R)

07685091 93140340 PMID: 1487912
A model for estimating corneal stiffness using an indenter.
Carnell P H; Vito R P
School of Mechanical Engineering, Georgia Institute of Technology, Atlanta 30332.
Journal of biomechanical engineering (UNITED STATES) Nov 1992, 114 (4) p549-52, ISSN 0148-0731 Journal Code: 7909584
Document type: Journal Article
Languages: ENGLISH
Main Citation Owner: NLM
Record type: Completed
A finite element model that simulates indentation of the cornea was generated to examine the feasibility of using indentation data to determine mechanical properties. A layered model which included geometric nonlinearities was necessary to characterize the indentation process. Results indicate that a secant modulus could be determined by measuring indenter force and contact area.
Record Date Created: 19930225
Record Date Completed: 19930225

30/7/44 (Item 44 from file: 94)
DIALOG(R)File 94:JICST-EPlus

01614866 JICST ACCESSION NUMBER: 92A0575397 FILE SEGMENT: JICST-E
Prognostic value of Simonsz's computer program in oblique muscle surgery.
HASEBE SATOSHI (1); OTSUKI HIROSHI (1); TADOKORO YASUNORI (1); WATANABE SEI (1); OKANO MASAKI (1)
(1) Okayama Univ., School of Medicine
Ganka Rinsho Iho(Japanese Review of Clinical Ophthalmology), 1992, VOL.86,NO.7, PAGE.1686-1689, FIG.2, TBL.1, REF.7
JOURNAL NUMBER: Z0646AAH ISSN NO: 0386-9601
UNIVERSAL DECIMAL CLASSIFICATION: 617.71/.78 617.7-089
LANGUAGE: Japanese COUNTRY OF PUBLICATION: Japan
DOCUMENT TYPE: Journal
ARTICLE TYPE: Original paper
MEDIA TYPE: Printed Publication
ABSTRACT: In 58 cases, we compared the results of our own surgery with the predictions of Simonsz's program retrospectively. In cases with large vertical deviation(V.D. in adduction>20 degrees), the prediction error was very large. Exception of such cases, the precision error in this predictions was reduced to 2.4-4.0 degrees in vertical deviations, 3.4 degrees in AV pattern, and 5.9 degrees in cyclodeviation(standard deviation). The advantage of this prediction program in clinical use is that we can determine the surgical method and dose based on plural parameters. Such a method was suitable for oblique muscle surgery because of its incomitant characters. (author abst.)

30/7/50 (Item 50 from file: 155)
DIALOG(R)File 155:MEDLINE(R)

06526913 90151996 PMID: 2620750
Computer simulation **of arcuate and radial incisions involving the corneoscleral limbus.**
Hanna K D; Jouve F E; Waring G O; Ciarlet P G

Ophthalmology Service, Hotel-Dieu Hospital, Paris, France.
Eye (London, England) (ENGLAND) 1989, 3 (Pt 2) p227-39, ISSN 0950-222X Journal Code: 8703986
Document type: Journal Article
Languages: ENGLISH
Main Citation Owner: NLM
Record type: Completed
We have created a **computer model** of the eye that improves upon previous models with two assumptions: (1) the cornea is considered anisotropic, and (2) the strain tensor is non-linear for large displacements. Values used include those for Young's modulus, Poisson's ratio, and three coefficients of anisotropia. A finite element computer program was used to stimulate the behaviour of the eye. Four simulations were done: (1) a full thickness arcuate limbal cataract incision, (2) a partial thickness arcuate corneal relaxing incision, (3) a partial thickness radial incision extending across the limbus, (4) a partial thickness radial incision confined to the cornea. A full thickness corneal arcuate incision for cataract induced more change in corneal shape than a limbal incision. However, the gaping is more important in the limbal incision. Partial thickness arcuate corneal relaxing incisions were found to be more effective with a clear zone 3-5 mm in diameter. Radial incision simulation demonstrated little enhancement of the effect of the incisions when across the limbus.
Record Date Created: 19900323
Record Date Completed: 19900323

30/7/52 (Item 52 from file: 144)
DIALOG(R)File 144:Pascal

08499818 PASCAL No.: 89-0048609
Computer simulation **of lamellar keratectomy and laser myopic keratomileusis**
HANNA K D; JOUVE F; BERCOVIER M H; WARING G O III
Hotel-Dieu hosp., dep. ophthalmology, Paris 75004, France
Journal: Journal of refractive surgery, 1988, 4 (6) 222-231
ISSN: 0883-0444 Availability: CNRS-21122
No. of Refs.: 26 ref.
Document Type: P (Serial) ; A (Analytic)
Country of Publication: USA
Language: English

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File  98:General Sci Abs/Full-Text 1984-2003/Jun
File   9:Business & Industry(R) Jul/1994-2003/Aug 12
File  16:Gale Group PROMT(R) 1990-2003/Aug 13
File 160:Gale Group PROMT(R) 1972-1989
File 148:Gale Group Trade & Industry DB 1976-2003/Aug 13
File 621:Gale Group New Prod.Annou.(R) 1985-2003/Aug 13
File 149:TGG Health&Wellness DB(SM) 1976-2003/Jul W4
File 636:Gale Group Newsletter DB(TM) 1987-2003/Aug 13
File 441:ESPICOM Pharm&Med DEVICE NEWS 2003/Aug W2
File  20:Dialog Global Reporter 1997-2003/Aug 13
File 444:New England Journal of Med. 1985-2003/Aug W2
```

Set	Items	Description
S1	3176064	SIMULAT? OR MODEL????
S2	5429592	COMPUTER OR COMPUTERI?ED
S3	2354601	DIGITAL OR DIGITI?ED
S4	5268599	SOFTWARE
S5	1322372	EYE OR EYES OR CORNEA? OR OPHTHALMOLOG?
S6	775941	SURGERY OR SURGERIES OR SURGICAL
S7	92189	S1(5N)S2
S8	36713	S1(5N)S3
S9	110078	S1(5N)S4
S10	18712	S5(5N)S6
S11	**1**	**S9(S)S10 [not relevant]**
S12	34	S9 AND S10
S13	26	RD (unique items)
S14	8	S13/2001:2003
S15	18	S13 NOT S14
S16	**18**	**Sort S15/ALL/PD,D**

16/8/7 (Item 7 from file: 16)
DIALOG(R)File 16:(c) 2003 The Gale Group. All rts. reserv.
06354125 Supplier Number: 54682642 (USE FORMAT 7 FOR FULLTEXT)
Stretched into sharp focus: computer models test a biomechanical explanation of traits in the human eye.
May, 1999
Word Count: 1397
PUBLISHER NAME: American Society of Mechanical Engineers
EVENT NAMES: *310 (Science & research)
GEOGRAPHIC NAMES: *1USA (United States)
PRODUCT NAMES: *7372000 (Computer Software); 8520110 (Scientists)
INDUSTRY NAMES: BUSN (Any type of business); ENG (Engineering and Manufacturing)
NAICS CODES: 51121 (Software Publishers); 54171 (Research and Development in the Physical, Engineering, and Life Sciences)
SPECIAL FEATURES: illustration; Chart
SPECIAL FEATURES: LOB

16/8/13 (Item 13 from file: 149)
DIALOG(R)File 149:(c) 2003 The Gale Group. All rts. reserv.
01602865 SUPPLIER NUMBER: 17463477 (USE FORMAT 7 OR 9 FOR FULL TEXT)
Climatic proteoglycan stromal keratopathy, a new corneal degeneration.
1995
WORD COUNT: 4927 LINE COUNT: 00499
SPECIAL FEATURES: illustration; photograph; table; diagram
DESCRIPTORS: Corneal diseases--Diagnosis

16/8/15 (Item 15 from file: 148)
DIALOG(R)File 148:(c)2003 The Gale Group. All rts. reserv.
06223974 SUPPLIER NUMBER: 14534764 (USE FORMAT 7 OR 9 FOR FULL TEXT)
Robotics, virtual worlds meet medicine.
Nov, 1992
WORD COUNT: 1952 LINE COUNT: 00163
SPECIAL FEATURES: illustration; chart
INDUSTRY CODES/NAMES: HLTH Healthcare
DESCRIPTORS: Virtual reality--Evaluation; Robotics--Evaluation; Imaging systems in medicine--Innovations
SIC CODES: 3823 Process control instruments; 3840 Medical Instruments and Supplies

16/3,AB,K/2 (Item 2 from file: 16)
DIALOG(R)File 16:Gale Group PROMT(R)
(c) 2003 The Gale Group. All rts. reserv.
07516884 Supplier Number: 62879601
Corneal topographers offer ophthalmologists choices.(Brief Article)
Mulligan, Margaret
Ophthalmology Times, v25, n11, p24
June 1, 2000
Language: English Record Type: Fulltext
Article Type: Brief Article
Document Type: Magazine/Journal; Trade
Word Count: 2318

Alcon **Surgical** offers the EyeMap EH-290 **Corneal** Topography System. The system has new, easy-to-use software to meet the diverse needs...
...laser: diode laser, wavelength 670 nm; laser output (less than) 20 (micro)W

C-Scan **software** : Basic **software** , plus optional **software** **models** , including:

Ray Tracing; 3D-elevation maps; 3D-elevation difference maps; astigmatism analysis; statistics; Snell's...corneal and pupil assessments. The units' ranges can be enhanced with flexible software programs for **corneal** analysis, refractive **surgery** , evaluation, and contact lens fitting.

Specifications and features:

ATLAS 993:

Working Distance: 70 mm

Field...

16/3,AB,K/3 (Item 3 from file: 16)
DIALOG(R)File 16:Gale Group PROMT(R)
(c) 2003 The Gale Group. All rts. reserv.
07201853 Supplier Number: 61410374
Phaco procedure modified with new technology : Surgeons have more efficient, controlled power for nucleus removal.
Fishkind, William J.
Ophthalmology Times, v25, n8, p10
April 15, 2000
Language: English Record Type: Fulltext
Document Type: Magazine/Journal; Trade
Word Count: 1955
... pumps have been modernized with precise command of pump speed and direction. Virtual anterior chamber **models** created by machine **software** emulate the actual fluidics of the anterior chamber, anticipating and thus preventing surge. Vacuum and...unique and creative ways.

William J. Fishkind, MD, FACS, is co-director, Fishkind and Bakewell **Eye** Care and **Surgical** Center, Tucson, AZ, and clinical professor of ophthalmology, University of Utah, Salt Lake City...

16/3,AB,K/5 (Item 5 from file: 16)
DIALOG(R)File 16:Gale Group PROMT(R)

07086808 Supplier Number: 59694240
Upgrades Map New Directions in Topography.(Statistical Data Included)
Eisenberg, Jeffrey S.
Review of Optometry, v137, n1, p39
Jan 15, 2000
Language: English Record Type: Fulltext
Article Type: Statistical Data Included
Document Type: Magazine/Journal; Refereed; Professional
Word Count: 1801
TEXT:
Do you still think a **corneal** topographer only belongs in **surgical** centers? Here are ways to extend its applications in optometric practice.
... for the disease. But it may tell you, 'I think we have keratoconus"'

Comanaging Refractive **Surgery**

Of course, **corneal** topography is the standard of care for screening refractive surgery candidates. Besides ruling out keratoconus...
...if the patient is suitable for refractive surgery. It also shows the elevation of the **cornea** in microns.

Bausch & Lomb **Surgical** 's Orbscan system, meanwhile, gets high marks from Lake Oswego, Ore., ophthalmic technician Patrick Caroline...the best fit for what's available for that particular lens type, and provides a **simulated** fluorescein pattern. The **software** also will rule out a spherical lens if the patient has significant astigmatism.

Oculus combines...
...to identify disease earlier, improve contact lens fitting and do a better job screening refractive **surgery** candidates. **Corneal** topography also may come in handy the next time you're faced with an atypical...

16/3,AB,K/14 (Item 14 from file: 149)
DIALOG(R)File 149:TGG Health&Wellness DB(SM)

01411477 SUPPLIER NUMBER: 13381384 (USE FORMAT 7 OR 9 FOR FULL TEXT)
Determination of corneal image-forming properties from corneal topography.
Maloney, Robert K.; Bogan, Stephen J.; Waring, George O., III
American Journal of Ophthalmology, v115, n1, p31(11)
Jan 15, 1993
PUBLICATION FORMAT: Magazine/Journal ISSN: 0002-9394 LANGUAGE: English
RECORD TYPE: Fulltext TARGET AUDIENCE: Professional
WORD COUNT: 5238 LINE COUNT: 00452
... in keratoconus and after penetrating keratoplasty, and can develop after radial keratotomy and other refractive **corneal** **surgical** procedures. It would be useful to have a method of measuring corneal shape that could...
...Bausch and Lomb keratometer, Bausch and Lomb, Rochester, New York), and videokeratography with the Corneal **Modeling** System (**software** version 1.3, Computed Anatomy, Inc., New York, New York) were performed on all enrolled...keratotomy. Refract. Corneal Surg. 5:394, 1989.

8. Uozato, H., and Guyton, D.L.: Centering **corneal** **surgical**

procedures. Am. J. Ophthalmol. 103:264, 1987.
9. Dingeldein, S.A., Klyce, S.D., and...

File 350:Derwent WPIX 1963-2003/UD,UM &UP=200351
File 347:JAPIO Oct 1976-2003/Apr(Updated 030804)
File 371:French Patents 1961-2002/BOPI 200209

Set	Items	Description
S1	162978	SIMULAT? OR MODEL????
S2	634013	COMPUTER OR COMPUTERI?ED
S3	450261	DIGITAL OR DIGITI?ED
S4	62271	SOFTWARE
S5	85356	EYE OR EYES OR CORNEA? OR OPHTHALMOLOG?
S6	53852	SURGERY OR SURGERIES OR SURGICAL
S7	18641	S1(S)S2:S4
S8	3157	S5(S)S6
S9	**8**	**S7 AND S8**

9/26,TI/1 (Item 1 from file: 350)
DIALOG(R)File 350:Derwent WPIX

015107296
WPI Acc No: 2003-167815/200316
Interactive training system for designing and performing training sessions for persons to perform procedures involving manual dexterity and/or hand- eye coordination e.g. medical surgical procedures

9/34/2 (Item 2 from file: 350)
DIALOG(R)File 350:Derwent WPIX

013131735 **Image available**
WPI Acc No: 2000-303606/200026
Diagnosing, analyzing and treating method for eye defects to be corrected by corneal laser ablation procedures change the surface curvature of the cornea to achieve required correction of vision
Patent Assignee: SCI OPTICS INC (SCOP-N)
Inventor: GRIERSON J; LIEBERMAN D M
Number of Countries: 090 Number of Patents: 009
Patent Family:

Patent No	Kind	Date	Applicat No	Kind	Date	Week	
WO 200019918	A1	20000413	WO 99US23209	A	19991001	200026	B
AU 9964156	A	20000426	AU 9964156	A	19991001	200036	
BR 9914455	A	20010522	BR 9914455	A	19991001	200132	
			WO 99US23209	A	19991001		
EP 1119300	A1	20010801	EP 99951794	A	19991001	200144	
			WO 99US23209	A	19991001		
KR 2001082218	A	20010829	KR 2001704104	A	20010330	200215	
US 6416179	B1	20020709	US 98102813	P	19981002	200253	
			WO 99US23209	A	19991001		
			US 2000646739	A	20000919		
JP 2002526149	W	20020820	WO 99US23209	A	19991001	200258	
			JP 2000573281	A	19991001		
US 20030055412	A1	20030320	US 98102813	P	19981002	200323	
			WO 99US23209	A	19991001		
			US 2000646739	A	20000919		
			US 2002154412	A	20020522		
AU 761214	B	20030529	AU 9964156	A	19991001	200346	

Priority Applications (No Type Date): US 98102813 P 19981002; US 2000646739 A 20000919; US 2002154412 A 20020522
Patent Details:

Patent No	Kind	Lan	Pg	Main IPC	Filing Notes
WO 200019918	A1	E	44	A61B-017/32	

Designated States (National): AE AL AM AT AU AZ BA BB BG BR BY CA CH CN CR CU CZ DE DK DM EE ES FI GB GD GE HR HU ID IL IN IS JP KE KG KP KR KZ LC LK LR LS LT LU LV MD MG MK MN MW MX NO NZ PL PT RO RU SD SE SG SI SK SL TJ TM TR TT UA UG US UZ VN YU ZA ZW

Designated States (Regional): AT BE CH CY DE DK EA ES FI FR GB GH GM GR IE IT KE LS LU MC MW NL OA PT SD SE SL SZ TZ UG ZW

Patent No	Kind	Lan	Pg	Main IPC	Filing Notes
AU 9964156	A				Based on patent WO 200019918
BR 9914455	A			A61B-017/32	Based on patent WO 200019918
EP 1119300	A1	E		A61B-017/32	Based on patent WO 200019918

Designated States (Regional): AL AT BE CH CY DE DK ES FI FR GB GR IE IT LI LT LU LV MC MK NL PT RO SE SI

Patent No	Kind	Lan	Pg	Main IPC	Filing Notes
KR 2001082218	A			A61F-009/013	
US 6416179	B1			A61B-003/10	Provisional application US 98102813 Based on patent WO 200019918
JP 2002526149	W		57	A61F-009/007	Based on patent WO 200019918
US 20030055412	A1			A61B-018/18	Provisional application US 98102813 Cont of application WO 99US23209 Cont of application US 2000646739 Cont of patent US 6416179
AU 761214	B			A61B-017/32	Previous Publ. patent AU 9964156 Based on patent WO 200019918

Abstract (Basic): WO 200019918 A1

NOVELTY - Corneal ablation of eye is performed in a manner which does not interfere with the natural shape of the cornea or its orientation relative to the remainder of the eye, but which changes its surface curvature appropriately to achieve the required correction of vision.

DETAILED DESCRIPTION - The method is performed with the aid of a **computer** system running a topological **modelling** **computer** program. The program, making use of sampled points on the cornea for which the coordinates are known relative to a reference plane, produces a surface **model** of the cornea which closely represents the surface of the cornea. The shape of the surface **model** is modified enough to change the radius of curvature at several selected sites to achieve a correction in vision indicated to be necessary by an eye test, without introducing changes in shape that are not associated with changing the radius of curvature, to produce a corrected surface **model** .

The method further involves at least one of viewing the surface model or the corrected surface model on a display device and using the corrected surface model to control laser ablation of the cornea.

INDEPENDENT CLAIMS are also included for a contact lens and for a shim apparatus.

USE - For correcting vision defects.

ADVANTAGE - Improved **surgical** method for **corneal** ablation procedure. Allows pre- **surgical** **eye** to be analyzed to predict post-operative condition to plan more effective **surgery** .

DESCRIPTION OF DRAWING(S) - The figure shows the laser ablating method of a cornea.

Eye (12)
Corneal image capture system (610)
Electron analysis program (620)
Computer aided design program (630)
Command processor (640)

```
        Cornea shaping system (650)
        pp; 44 DwgNo 1/6
Derwent Class: P31; P32; S05; T01
International Patent Class (Main): A61B-017/32; A61B-018/18; A61F-009/007;
  A61F-009/013
International Patent Class (Additional): A61B-003/10; A61B-018/20
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9/34/3 (Item 3 from file: 350)

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DIALOG(R)File 350:Derwent WPIX
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012803585     **Image available**
WPI Acc No: 1999-609815/199952
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Refractive surgical **method of** eye **e.g. astigmatic keratotomy, epikeratophakia**

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Patent Assignee: EYESYS PREMIER INC (EYES-N)
Inventor: PALLIKARIS I G; THORNTON S P; WAKIL Y S
Number of Countries: 001  Number of Patents: 001
Patent Family:
Patent No      Kind   Date     Applicat No     Kind   Date     Week
US 5970984      A   19991026  US 9360127       A   19930510  199952  B
                              US 94355436      A   19941213
                              US 97956878      A   19971023
Priority Applications (No Type Date): US 9360127 A 19930510; US 94355436 A
  19941213; US 97956878 A 19971023
Patent Details:
Patent No  Kind Lan Pg   Main IPC     Filing Notes
US 5970984    A     17 A61B-019/00   Cont of application US 9360127
                                     Cont of application US 94355436
                                     Cont of patent US 5722427
```

Abstract (Basic): US 5970984 A

NOVELTY - Corneal topography data is obtained by examining eye using corneal topographer. The optical zones are selected and correlated dioptric power curves are constructed based on obtained topographic data. The incisions are made on predetermined locations in the cornea, based on dioptric power curve and patient factor.

DETAILED DESCRIPTION - An INDEPENDENT CLAIM is also included for refractive surgical apparatus.

USE - For performing refractive **surgery** of **eye** e.g. astigmatic keratotomy, epikeratophakia, radial keratotomy, excimer laser **surgery** , photorefractive keratectomy etc.

ADVANTAGE - The combination of patient factor analysis and dioptric power curve analysis yields accurate and quantitative surgical process. **Computer** determines optimized method because it **simulates** surgical results using quantitative analysis. It is possible to employ various instruments and technique for precise incision placement, because locations are predetermined.

DESCRIPTION OF DRAWING(S) - The figure explains the refractive surgical method.

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        pp; 17 DwgNo 5/12
Derwent Class: P31
International Patent Class (Main): A61B-019/00
```

9/34/4 (Item 4 from file: 350)

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DIALOG(R)File 350:Derwent WPIX
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012020770 .  **Image available**
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WPI Acc No: 1998-437680/199837
Simulator **of ophthalmic** surgery **for reshaping of** corneal **surface for correcting** eye **disorders - has laser generating laser beam projected at array with** computer **system operatively connected adapted to actuate and creates ablation profile based on laser beam**
Patent Assignee: LASERSIGHT TECHNOLOGIES INC (LASE-N)
Inventor: YAVITZ E Q
Number of Countries: 081 Number of Patents: 003
Patent Family:

Patent No	Kind	Date	Applicat No	Kind	Date	Week	
WO 9834212	A1	19980806	WO 98US1653	A	19980130	199837	B
AU 9862535	A	19980825	AU 9862535	A	19980130	199903	
US 6210169	B1	20010403	US 97792888	A	19970131	200120	

Priority Applications (No Type Date): US 97792888 A 19970131
Patent Details:

Patent No	Kind	Lan	Pg	Main IPC	Filing Notes
WO 9834212	A1	E	16	G09B-023/28	

Designated States (National): AL AM AT AU AZ BA BB BG BR BY CA CH CN CU CZ DE DK EE ES FI GB GE GH GM GW HU ID IL IS JP KE KG KP KR KZ LC LK LR LS LT LU LV MD MG MK MN MW MX NO NZ PL PT RO RU SD SE SG SI SK SL TJ TM TR TT UA UG UZ VN YU ZW
Designated States (Regional): AT BE CH DE DK EA ES FI FR GB GH GM GR IE IT KE LS LU MC MW NL OA PT SD SE SZ UG ZW

Patent No	Kind	Lan	Pg	Main IPC	Filing Notes
AU 9862535	A			G09B-023/28	Based on patent WO 9834212
US 6210169	B1			G09B-023/28	

Abstract (Basic): WO 9834212 A

The device comprises a laser (12) to generate a laser beam (14). A array (16) is adapted to sense whether the beam has been projected at the array. A computer system (18) is operatively connected to the laser and the array, and is adapted to actuate the later. it also determines whether the array has senesced the laser beam, and creates an ablation profile based on the laser beam sensed by the array.

The **computer** system comprises a unit providing a three dimensional view of the ablation profile. The array comprises photovoltaic sensor devices, which are arranged in the form of a grid. Also is provided fibre optic elements arranged to **simulate** the contour of a cornea.

ADVANTAGE - Can be easily employed with high reliable result, and simulate the ablation profile of the cornea by directly translating actual laser energy pulses into a three dimensional view of the cornea.

Dwg.1/6

Derwent Class: P31; P85; S05
International Patent Class (Main): G09B-023/28
International Patent Class (Additional): A61B-017/36; A61B-018/18

9/34/5 (Item 5 from file: 350)
DIALOG(R)File 350:Derwent WPIX

011591481 **Image available**
WPI Acc No: 1998-008610/199801
Corneal **laser** surgery simulating **apparatus - includes** digital **data processing system generating** simulated **post-operative topography of** cornea **as function of location, based on parameters of proposed laser ablation procedure**
Patent Assignee: PAR TECHNOLOGY CORP (PART-N); PARTECH INC (PART-N)
Inventor: CAMBIER J L; ROZAKIS G W

Number of Countries: 019 Number of Patents: 003
Patent Family:

Patent No	Kind	Date	Applicat No	Kind	Date	Week	
WO 9743006	A1	19971120	WO 97US8037	A	19970513	199801	B
US 5843070	A	19981201	US 96645100	A	19960513	199904	
EP 904131	A1	19990331	EP 97924686	A	19970513	199917	
			WO 97US8037	A	19970513		

Priority Applications (No Type Date): US 96645100 A 19960513
Patent Details:
Patent No Kind Lan Pg Main IPC Filing Notes
WO 9743006 A1 E 30 A61N-005/02
Designated States (National): JP
Designated States (Regional): AT BE CH DE DK ES FI FR GB GR IE IT LU MC NL PT SE
EP 904131 A1 E A61N-005/02 Based on patent WO 9743006
Designated States (Regional): DE GB IT
US 5843070 A A61M-005/06
Abstract (Basic): WO 9743006 A

The laser **surgery simulating** system includes a **digital** data processing apparatus (18) configured to receive data defining a pre-operative topography of the **cornea** as a function of location, to obtain parameters of the proposed laser ablation procedure from which the **digital** data processing system can determine the amount of **cornea** expected to be ablated as a function of location on the **cornea** . Based on the data and the parameters, the **digital** processing system produces an output representing a **simulated** post-operative topography of the **cornea** as a function of location.

The **simulating** system further includes a visual display system (20) connected to the **digital** data processing system for receiving the output of the **digital** data processing system and for displaying the **simulated** post-operative topography of the cornea as a function of location. Preferably, the data processing system receives from an external processor (26) that operates a laser (24) that performs the laser ablation procedure information pertaining to the amount of cornea expected to be ablated as a function of location.

USE - In photorefractive keratectomy surgery for correcting myopia and hyperopia.

Dwg.3/9

Derwent Class: P34; S05
International Patent Class (Main): A61M-005/06; A61N-005/02

9/34/6 (Item 6 from file: 350)
DIALOG(R)File 350:Derwent WPIX

009981763 **Image available**
WPI Acc No: 1994-249477/199430

Testing and calibrating the intensity of a surgical **laser - using imitation human** cornea **with superimposed parallel layers of polymethyl-methacrylate and collagen of different thickness and colour**

Patent Assignee: IATROTECH INC (IATR-N); NOVARTIS AG (NOVS); CIBA-GEIGY AG (CIBA); NOVARTIS-ERFINDUNGEN VERW GES MBH (NOVS)
Inventor: HALL D K; RENCS E
Number of Countries: 020 Number of Patents: 008
Patent Family:

Patent No	Kind	Date	Applicat No	Kind	Date	Week	
WO 9416425	A1	19940721	WO 93US12378	A	19931220	199430	B

AU 9458526	A	19940815	AU 9458526	A	19931220	199442
EP 681724	A1	19951115	WO 93US12378	A	19931220	199550
			EP 94904501	A	19931220	
US 5464960	A	19951107	US 933521	A	19930112	199550
			US 93150603	A	19931110	
EP 681724	A4	19960626	EP 94904501	A	19940000	199644
EP 681724	B1	19990804	WO 93US12378	A	19931220	199935
			EP 94904501	A	19931220	
DE 69325925	E	19990909	DE 625925	A	19931220	199943
			WO 93US12378	A	19931220	
			EP 94904501	A	19931220	
ES 2136727	T3	19991201	EP 94904501	A	19931220	200005

Priority Applications (No Type Date): US 93150603 A 19931110; US 933521 A 19930112

Cited Patents: 00 55912600; Jnl.Ref; US 4676790; WO 8806329

Patent Details:

Patent No Kind Lan Pg Main IPC Filing Notes

WO 9416425 A1 E 24 G09B-023/28

Designated States (National): AU JP US

Designated States (Regional): AT BE CH DE DK ES FR GB GR IE IT LU MC NL PT SE

ES 2136727 T3 G09B-023/28 Based on patent EP 681724

AU 9458526 A G09B-023/28 Based on patent WO 9416425

EP 681724 A1 E G09B-023/28 Based on patent WO 9416425

Designated States (Regional): AT BE CH DE ES FR GB GR IT LI NL SE

US 5464960 A 9 B23K-026/02 CIP of application US 933521

CIP of patent US 5261822

EP 681724 B1 E G09B-023/28 Based on patent WO 9416425

Designated States (Regional): AT BE CH DE ES FR GB GR IT LI NL SE

DE 69325925 E G09B-023/28 Based on patent EP 681724

Based on patent WO 9416425

EP 681724 A4 G09B-023/28

Abstract (Basic): WO 9416425 A

An artificial optical body has superimposed parallel layers (6 to 9) of a material that is ablatable by a **surgical** laser. The material has the same effect as a human **cornea** when ablated by a laser. Contiguous layers of the body have different optical characteristics, pref. alternating colours, and thickness.

Pref. the layers are thin films of polymethyl-methacrylate and collagen doped with a fluorescent compound. The films may be epitaxially-grown, vapour-deposited, soln-coated or a multi-layer Langmuir-Blodgett film.

Also claimed is a method of calibrating and testing a laser using the target.

USE/ADVANTAGE - The body is for testing and calibrating the intensity of a surgical laser. Quick and convenient method of calibrating a laser is provided.

Dwg.2/8

Abstract (Equivalent): US 5464960 A

A tissue-ablative pulsed laser beam is used by first counting the number of pulses needed to ablate a specific area of constant-thickness ablatable target material (5), dividing the thickness by the number to obtain an ablating factor, and applying to tissue a number of pulses proportional to the ratio of depth over factor.

Two successive target areas may be ablated and the results used to form a combined factor. The effect of the beam on the target is

observed, pref. by taking images of the target between successive pulses and breaking the images into **digitised** arrays. The target is pref. a layer of polymethylmethacrylate, or an epitaxial, vapour-deposited, Langmuir-Blodgett or spin-coated film. Also claimed is a method for adjusting circular cross-section beam intensity using a target shaped to **simulate** a human cornea and with superimposed layers.

USE - Partic. for use in ophthalmic **surgery** when removing diseased tissue or changing the curvature of the **cornea** .

ADVANTAGE - Permits rapid calibration and recalibration and is suitable for use in an operating theatre.

Dwg.2/8

Derwent Class: A89; P32; P55; P85; S03; S05
International Patent Class (Main): B23K-026/02; G09B-023/28
International Patent Class (Additional): A61F-009/00; G09B-023/30

9/34/7 (Item 7 from file: 350)
DIALOG(R)File 350:Derwent WPIX

008066824 **Image available**
WPI Acc No: 1989-331936/198945

Topographical modelling **for anatomical surfaces - using two low powered lasers to position video image and** computer **to process measurement**

Patent Assignee: COMPUTED ANATOMY (COMP-N)
Inventor: GERSTEN M; MAMMONE J
Number of Countries: 001 Number of Patents: 001
Patent Family:

Patent No	Kind	Date	Applicat No	Kind	Date	Week	
US 4863260	A	19890905	US 88289515	A	19881227	198945	B

Priority Applications (No Type Date): US 87117020 A 19871104; US 88289515 A 19881227
Patent Details:

Patent No	Kind	Lan	Pg	Main IPC	Filing Notes
US 4863260	A		14		

Abstract (Basic): US 4863260 A

A video image of the corneal surface accurately positioned at a predetermined point on the optic axis of measurement is obtained. The predetermined point is defined by intersecting low power laser beams. The video image is radially scanned from an original position at point defined by the intersection of the visual axis with corneal surface. Accurate measurements of the two-dimensional image radii of a set of illuminated mires reflective upon the corneal surface are made and corrected for camera distortions, quantisation error and the different magnification occurring for different size corneas.

The instrumentation is calibrated by using a set of mirror-like spheres of precisely known spherical radii.

USE - **Eye** **surgery** .

1/8

Derwent Class: P31; S05
International Patent Class (Additional): A61B-003/10

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File 348:EUROPEAN PATENTS 1978-2003/Jul W03
File 349:PCT FULLTEXT 1979-2002/UB=20030807,UT=20030731
Set      Items    Description
S1      272578    SIMULAT? OR MODEL????
S2      257384    COMPUTER OR COMPUTERI?ED
S3      215107    DIGITAL OR DIGITI?ED
S4      157738    SOFTWARE
S5       77308    EYE OR EYES OR CORNEA? OR OPHTHALMOLOG?
S6       64883    SURGERY OR SURGERIES OR SURGICAL
S7       23667    S1(5N)S2:S4
S8        5338    S5(S)S6
S9          17    S7(S)S8
```

9/6/6 (Item 3 from file: 349)
00923116 **Image available**
KERATOMETRIC TO APICAL RADIUS CONVERSION

9/6/16 (Item 13 from file: 349)
00276792 **Image available**
TRACKING SYSTEM FOR LASER SURGERY

9/3,AB/7 (Item 4 from file: 349)
DIALOG(R)File 349:PCT FULLTEXT

00873981
METHODS AND INSTRUMENTS FOR REFRACTIVE OPHTHALMIC SURGERY
PROCEDES ET APPAREILS DESTINES A AMELIORER LA CHIRURGIE OPHTALMIQUE REFRACTIVE
Patent Applicant/Assignee:
OHIO STATE UNIVERSITY, 1960 Kenny Road, Columbus, OH 43210-1063, US, US (Residence), US (Nationality), (For all designated states except: US)
Patent Applicant/Inventor:
ROBERTS Cynthia, 1667 Moreland Drive, Columbus, OH 43220, US, US (Residence), US (Nationality), (Designated only for: US)
DUPPS William J Jr, 1711 Gleason Avenue, Iowa City, IA 52240, US, US (Residence), US (Nationality), (Designated only for: US)
KATSUBE Noriko, 1381 Tiehack Ct., Columbus, OH 43235, US, US (Residence), US (Nationality), (Designated only for: US)
Legal Representative:
RICH James A (agent), Calfee, Halter & Griswold LLP, 1400 McDonald Investment Center, 800 Superior Avenue, Cleveland, OH 44114-2688, US,
Patent and Priority Information (Country, Number, Date):
Patent: WO 200207660 A2-A3 20020131 (WO 0207660)
Application: WO 2001US22936 20010720 (PCT/WO US0122936)
Priority Application: US 2000220019 20000721
Designated States: AE AG AL AM AT AU AZ BA BB BG BR BY BZ CA CH CN CO CR CU CZ DE DK DM DZ EE ES FI GB GD GE GH GM HR HU ID IL IN IS JP KE KG KP KR KZ LC LK LR LS LT LU LV MA MD MG MK MN MW MX MZ NO NZ PL PT RO RU SD SE SG SI SK SL TJ TM TR TT TZ UA UG US UZ VN YU ZA ZW
(EP) AT BE CH CY DE DK ES FI FR GB GR IE IT LU MC NL PT SE TR
(OA) BF BJ CF CG CI CM GA GN GQ GW ML MR NE SN TD TG
(AP) GH GM KE LS MW MZ SD SL SZ TZ UG ZW
(EA) AM AZ BY KG KZ MD RU TJ TM
Publication Language: English
Filing Language: English
Fulltext Word Count: 18123

English Abstract

Biomechanical responses of the eye are used to improve photorefractive procedures. LASIK or PRK treatments, for example, can be improved by taking pre-operative measurement and predicting the corneas's biodynamic response to the ablative treatment. Predicitve use is mad of the biodynamic response of the cornea due to laser or mechanical keratectomy, that is, creating a corneal flap characterisitc of LASIK. Comparison of pre-flap and post-flap, (pre-ablation) data of the cornea such as corneal thickness, flap thickness, corneal topography and wavefront, for example, can provide predictive information applicable to modifying an ablation alorithm before the laser is engaged, either for a current operation or the development of a model. Modeling, by finite element analysis or other mathematical techniques, can also be used to predict post-operative outcomes based on a pre-operative (no flap cut or other surgical intervention) data for the cornea that is input for an accurate eye model that, in consideration of biodynamic response <i>via</i> the model, provides predictive information for optimizing the sucess of the refractive surgery and ultimately patient satisfaction.

9/3,AB/8 (Item 5 from file: 349)
DIALOG(R)File 349:PCT FULLTEXT

00791575
PROLATE SHAPED CORNEAL RESHAPING
REPROFILAGE ALLONGE DE LA CORNEE

Patent Applicant/Assignee:
LASERSIGHT TECHNOLOGIES INC, Suite 140, 3300 University Blvd., Winter Park, FL 32792, US, US (Residence), US (Nationality)
Inventor(s):
HOLLADAY Jack T, 5108 Braeburn Drive, Bellaire, TX 77401, US,
SMITH Michael, 10143 Rivers Trail Drive, Orlando, FL 32817, US,
TERRY Travis, 5824 Auvers Blvd., #105, Orlando, FL 32807, US,
MARROU Lance, 9313 Pine Meadows Ct., Orlando, FL 32825, US,
Legal Representative:
BOLLMAN William H (agent), Manelli Denison & Selter PLLC, Suite 700, 2000 M Street, N.W., Washington, DC 20036-3307, US,
Patent and Priority Information (Country, Number, Date):
Patent: WO 200124728 A2-A3 20010412 (WO 0124728)
Application: WO 2000US27425 20001005 (PCT/WO US0027425)
Priority Application: US 99157803 19991005; US 2000223728 20000808
Designated States: AE AG AL AM AT AU AZ BA BB BG BR BY BZ CA CH CN CR CU CZ DE DK DM DZ EE ES FI GB GD GE GH GM HR HU ID IL IN IS JP KE KG KP KR KZ LC LK LR LS LT LU LV MA MD MG MK MN MW MX MZ NO NZ PL PT RO RU SD SE SG SI SK SL TJ TM TR TT TZ UA UG UZ VN YU ZA ZW
(EP) AT BE CH CY DE DK ES FI FR GB GR IE IT LU MC NL PT SE
(OA) BF BJ CF CG CI CM GA GN GW ML MR NE SN TD TG
(AP) GH GM KE LS MW MZ SD SL SZ TZ UG ZW
(EA) AM AZ BY KG KZ MD RU TJ TM
Publication Language: English
Filing Language: English
Fulltext Word Count: 6374
English Abstract

Apparatus (300) and techniques for performing prolate shaped corneal reshaping. In accordance with the techniques, an ablation scanning (380) laser system includes fitter (320) modules to fit input refractive or topographical measurement data to a three (3) variable ellipsoid model.

This provides pre- and post-operative approximations of a cornea. A desired prolate shaped ablation profile is determined based on a desired prolate ellipsoidal shape. In accordance with the principles of the present invention, the spheroequivalent ellipsoid model has only three degrees of freedom (not four as in a conventional biconic technique) to define a desired ablation profile, providing extremely accurate and predictable long term vision correction. To arrive at an ellipsoid model having only three numbers of freedom, a spheroequivalent (SEQ) value of asphericity QSEQ is generated. The spheroequivalent eccentricity QSEQ value replaces two degrees of freedom (i.e., eccentricities) in an otherwise conventional biconic modeling system, leaving only three (3) variables to determine for a best fit ellipsoidal modeling of a cornea possible, and to limit results to regular astigmatism that can be corrected with optical spherocylinders.

9/3,AB/11 (Item 8 from file: 349)
DIALOG(R)File 349:PCT FULLTEXT

00451945
METHOD, IMPLANT, AND APPARATUS FOR REFRACTIVE KERATOPLASTY
PROCEDE, IMPLANT ET APPAREIL DE KERATOPLASTIE REFRACTIVE
Patent Applicant/Assignee:
SAWUSCH Mark R,
Inventor(s):
SAWUSCH Mark R,
Patent and Priority Information (Country, Number, Date):
Patent: WO 9842409 A1 19981001
Application: WO 98US5720 19980324 (PCT/WO US9805720)
Priority Application: US 97823149 19970325
Designated States: AU BR JP MX SG AT BE CH DE DK ES FI FR GB GR IE IT LU MC NL PT SE
Fulltext Word Count: 4835
English Abstract
A method, implant, and apparatus to alter the refractive power of the cornea. The method involves creation of radial, intrastromal corneal incisions and insertion of semirigid, biocompatible implants (13). An apparatus (26) is provided to facilitate creation of the incisions with precise depth, orientation, and dimension. The implants (13) are of predetermined shape and curvature in accordance with the patient's pre-existing refractive error and corneal curvature. The implants (13) induce a predictable and stable flattening or steepening of corneal curvature for the correction of refractive errors. If residual refractive error is present following this procedure, the curvature or dimensions of the implants may be selectively increased or decreased by application of laser or other energy source to a heat-shrinkable portion of the implants, thereby eliminating residual refractive error.

9/3,AB/12 (Item 9 from file: 349)
DIALOG(R)File 349:PCT FULLTEXT

00402262
SIMULATING CORNEAL LASER SURGERY
SIMULATION DE CHIRURGIE CORNEENNE AU LASER
Patent Applicant/Assignee:
PAR TECHNOLOGY CORPORATION,
Inventor(s):

CAMBIER James L,
ROZAKIS George W,
Patent and Priority Information (Country, Number, Date):
Patent: WO 9743006 A1 19971120
Application: WO 97US8037 19970513 (PCT/WO US9708037)
Priority Application: US 96645100 19960513
Designated States: JP AT BE CH DE DK ES FI FR GB GR IE IT LU MC NL PT SE
Publication Language: English
Fulltext Word Count: 5880
English Abstract

An apparatus and method are provided for simulating a predicted post-operative topography of a cornea of an eye based on a pre-operative topography of the cornea, and a proposed laser ablation procedure. A digital data processing system (18) receives data defining a pre-operative topography of the cornea as a function of location, and obtains parameters of the proposed laser ablation procedure from which the digital data processing system (18) can determine the amount of cornea expected to be ablated as a function of location on the cornea. Based on the data and the parameters, the digital data processing system (18) produces an output representing a simulated post-operative topography of the cornea as a function of location. The parameters of the proposed laser ablation procedure specify variations in a cut rate of the laser beam (such as data specifying a plurality of laser beam cut rates for each of a corresponding plurality of laser beam pulses, or data specifying relative laser beam energy level, or fluency at each of a plurality of points within the laser beam).

9/3,AB/14 (Item 11 from file: 349)
DIALOG(R)File 349:PCT FULLTEXT

00373639
METHOD AND APPARATUS FOR IMPROVING VISION
PROCEDE ET APPAREIL DESTINE A AMELIORER LA VISION
Patent Applicant/Assignee:
SCIENTIFIC OPTICS INC,
LIEBERMAN David M,
GRIERSON Jonathan,
Inventor(s):
LIEBERMAN David M,
GRIERSON Jonathan,
Patent and Priority Information (Country, Number, Date):
Patent: WO 9714382 A1 19970424
Application: WO 96US17463 19961017 (PCT/WO US9617463)
Priority Application: US 955571 19951018; US 9616352 19960430
Designated States: AL AM AT AU AZ BA BB BG BR BY CA CH CN CU CZ DE DK EE ES FI GB GE HU IL IS JP KE KG KP KR KZ LC LK LR LS LT LU LV MD MG MK MN MW MX NO NZ PL PT RO RU SD SE SG SI SK TJ TM TR TT UA UG US UZ VN KE LS MW SD SZ UG AM AZ BY KG KZ MD RU TJ TM AT BE CH DE DK ES FI FR GB GR IE IT LU MC NL PT SE BF BJ CF CG CI CM GA GN ML MR NE SN TD TG
Publication Language: English
Fulltext Word Count: 12065
English Abstract

Methods and apparatus are disclosed for causing the optical center of the eye to align "HIGH point" of the anterior surface of the cornea. In accordance with one aspect of the invention relating to corneal ablation procedures, the "HIGH point" (14) of the eye is used as the pole of a

spherical surface which is fitted approximately to a portion of the anterior surface of the cornea within a "bounded region" (16). For corneal ablation procedures, the "bounded region" comprises a generally inverted cup shaped region of the anterior surface of the eye bounded at its periphery by a plane (BP) which is substantially perpendicular to a local z-axis. During the operation local high points which project above the spherical surface are ablated. According to another aspect of the invention relating to radial keratotomy procedures, a pair of incisions (b, b') in the plane of a "great circle" are formed in the cornea to weaken and flatten it. As used herein, a "great circle" is formed by a plane containing the "HIGH point" and parallel tothe local z-axis. The "bounded region" for radial keratotomy procedures is defined absolutely in terms of a circle projected onto the corneal surface which is centered about an axis passing through the "HIGH point" and parallel to the z-axis.

9/3,AB/17 (Item 14 from file: 349)
DIALOG(R)File 349:PCT FULLTEXT

00199506
ADJUSTABLE REPROFILING OF SYNTHETIC LENTICULES
MODIFICATION AJUSTABLE DU PROFIL DE LENTICULES SYNTHETIQUES
Patent Applicant/Assignee:
THOMPSON Keith P,
LIU Yung Sheng,
BANKS Seth Richard,
GAILITIS Raymond P,
Inventor(s):
THOMPSON Keith P,
LIU Yung Sheng,
BANKS Seth Richard,
GAILITIS Raymond P,
Patent and Priority Information (Country, Number, Date):
Patent: WO 9116865 A1 19911114
Application: WO 91US2978 19910501 (PCT/WO US9102978)
Priority Application: US 90378 19900502
Designated States: JP KR
Publication Language: English
Fulltext Word Count: 6626
English Abstract
An apparatus and process for applying a synthetic lenticule to the cornea of a human eye is disclosed, the process also contemplating selective reprofiling of the lenticule while it is in place over the cornea. The process involves securing the lenticule (140) over the cornea (24) with an adhesive (56), thus leaving the visual axis of the eye undisturbed or with the peripheral edge (152) thereof being retained by a peripheral slit. A laser deliver system is used to reprofile the lenticule if necessary for refining the refractive power of the lenticule.

```
File 350:Derwent WPIX 1963-2003/UD,UM &UP=200351
File 347:JAPIO Oct 1976-2003/Apr(Updated 030804)
File 371:French Patents 1961-2002/BOPI 200209
Set     Items   Description
S1          3   AU='SARVER E'
S2         15   AU='SARVER E J'
S3         81   VISION AND ALGORITHM
S4          1   S2 AND S3
S5          1   S1 AND S3
S6          0   S5 NOT S4
```

4/7/1 (Item 1 from file: 350)
DIALOG(R)File 350:Derwent WPIX

014659293 **Image available**
WPI Acc No: 2002-479997/200251
Optical correction of aberrant human vision **, uses intervention** algorithm **for constructing improved optical model, and applies procedures to achieve greater precision in optical correction**
Patent Assignee: SARVER & ASSOC (SARV-N); SARVER E J (SARV-I)
Inventor: **SARVER E J** ; SARVER E
Number of Countries: 096 Number of Patents: 003
Patent Family:

```
Patent No       Kind   Date     Applicat No      Kind   Date      Week
WO 200243581     A2   20020606  WO 2001US44875    A    20011128  200251  B
US 20020103479   A1   20020801  US 2000250296     A    20001130  200253
                                US 2001997159     A    20011128
AU 200252769     A    20020611  AU 200252769      A    20011128  200264
```

Priority Applications (No Type Date): US 2001997159 A 20011128; US 2000250296 P 20001130
Patent Details:

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Patent No  Kind Lan Pg   Main IPC     Filing Notes
WO 200243581   A2 E  19 A61B-003/00
   Designated States (National): AE AG AL AM AT AU AZ BA BB BG BR BY BZ CA
   CH CN CO CR CU CZ DE DK DM DZ EE ES FI GB GD GE GH GM HR HU ID IL IN IS
   JP KE KG KP KR KZ LC LK LR LS LT LU LV MA MD MG MK MN MW MX MZ NO NZ PL
   PT RO RU SD SE SG SI SK SL TJ TM TR TT TZ UA UG UZ VN YU ZA ZW
   Designated States (Regional): AT BE CH CY DE DK EA ES FI FR GB GH GM GR
   IE IT KE LS LU MC MW MZ NL OA PT SD SE SL SZ TR TZ UG ZM ZW
US 20020103479 A1       A61B-018/18   Provisional application US 2000250296
AU 200252769  A         A61B-003/00   Based on patent WO 200243581
```

Abstract (Basic): WO 200243581 A2

NOVELTY - The inventive method optimises the prediction of a **vision** correction procedure, by comparing historical data including the **vision** defect requiring correction with a suggested method/result. Wavefront aberrations and the patient's condition are taken into account in selecting an acceptable procedure. The patient's eye is examined, an optical model is created, and compared with the historical data for selecting the acceptable procedure. This is then carried out, and the result included in the historical database.

USE - For improving predictability of known methods for optical **vision** correction, using an advanced **vision** intervention **algorithm** (AVIA).

ADVANTAGE - The AVIA increases the measure of predictability, accommodating the many variations found in parameters describing the human eye, hence optimising virtually any current or anticipated

intervention method, one particular category where prediction may have been imperfect in the prior art being that of surgery to remove cataracts where refractive surgery has previously been carried out.

DESCRIPTION OF DRAWING(S) - The drawing illustrates a block flow diagram of a preferred embodiment of the inventive method and associated principles.

pp; 19 DwgNo 1/4

Derwent Class: P31

International Patent Class (Main): A61B-003/00; A61B-018/18

File 348:EUROPEAN PATENTS 1978-2003/Jul W03
File 349:PCT FULLTEXT 1979-2002/UB=20030807,UT=20030731

Set	Items	Description
S1	16	AU='SARVER EDWIN' OR AU='SARVER EDWIN J' OR AU='SARVER ED'
S2	100385	ALGORITHM?
S3	11	S1 AND S2
S4	25375	VISION
S5	**9**	**S3 AND S4**

5/3,AB/2 (Item 1 from file: 349)
DIALOG(R)File 349:PCT FULLTEXT

01005323
STEREO VIEW REFLECTION CORNEAL TOPOGRAPHY
TOPOGRAPHIE DE CORNEE PAR REFLEXION STEREOSCOPIQUE
Patent Applicant/Assignee:
LASERSIGHT TECHNOLOGIES INC, 3300 University Blvd., Suite 140, Winter Park, FL 32792, US, US (Residence), US (Nationality)
Inventor(s):
SARVER Ed , 3425 Savannahs Trail, Merritt Island, FL 32953, US,
LIU David, 46 Oakdale, Irvine, CA 92604, US
Legal Representative:
BOLLMAN William H (agent), Manelli Denison & Selter PLLC, 2000 M Street, N.W., Suite 700, Washington, DC 20036-3307, US,
Patent and Priority Information (Country, Number, Date):
Patent: WO 200334910 A1 20030501 (WO 0334910)
Application: WO 2001US32580 20011022 (PCT/WO US0132580)
Priority Application: WO 2001US32580 20011022
Designated States: AE AG AL AM AT AU AZ BA BB BG BR BY BZ CA CH CN CO CR CU CZ DE DK DM DZ EC EE ES FI GB GD GE GH GM HR HU ID IL IN IS JP KE KG KP KR KZ LC LK LR LS LT LU LV MA MD MG MK MN MW MX MZ NO NZ PL PT RO RU SD SE SG SI SK SL TJ TM TR TT TZ UA UG UZ VN YU ZA ZW
(EP) AT BE CH CY DE DK ES FI FR GB GR IE IT LU MC NL PT SE TR
(OA) BF BJ CF CG CI CM GA GN GQ GW ML MR NE SN TD TG
(AP) GH GM KE LS MW MZ SD SL SZ TZ UG ZW
(EA) AM AZ BY KG KZ MD RU TJ TM
Publication Language: English
Filing Language: English
Fulltext Word Count: 5000
English Abstract
A stereo target corneal topography apparatus and method that uses two differently angled views (C2), (C3) of a target pattern reflected from a cornea to measure the shape of a cornea eye (100) using a stereo reconstruction module to reconstruct the shape of a surface of a cornea. The surface elevation, surface slope and/or surface power may be determined without the need to make an initial assumption about the shape of the cornea.

5/3,AB/3 (Item 2 from file: 349)
DIALOG(R)File 349:PCT FULLTEXT

00949303
STEREOSCOPIC MEASUREMENT OF CORNEA AND ILLUMINATION PATTERNS
MESURE STEREOSCOPIQUE DE LA CORNEE ET MOTIFS D'ECLAIRAGE
Patent Applicant/Assignee:
LASERSIGHT TECHNOLOGIES INC, 3300 University Blvd., Suite 140, Winter

Park, FL 32792, US, US (Residence), US (Nationality)
Inventor(s):
LIU David, 1102 Shadowbrook Trail, Winter Springs, FL 32708, US,
SARVER Edwin J , 3425 Savannahs Trail, Merritt Island, FL 32953, US,
TROENDLE Dale, 6848 Stapoint Court, Winter Park, FL 32792, US
Legal Representative:
BOLLMAN William H (agent), Manelli Denison & Selter Pllc, Suite 700, 2000 M Street, NW, Washington, DC 20036-3307, US,
Patent and Priority Information (Country, Number, Date):
Patent: WO 200282980 A2-A3 20021024 (WO 0282980)
Application: WO 2002US11913 20020416 (PCT/WO US0211913)
Priority Application: US 2001283625 20010416; US 2001283627 20010416
Designated States: AE AG AL AM AT AU AZ BA BB BG BR BY BZ CA CH CN CO CR CU CZ DE DK DM DZ EC EE ES FI GB GD GE GH GM HR HU ID IL IN IS JP KE KG KP KR KZ LC LK LR LS LT LU LV MA MD MG MK MN MW MX MZ NO NZ OM PH PL PT RO RU SD SE SG SI SK SL TJ TM TN TR TT TZ UA UG UZ VN YU ZA ZM ZW
(EP) AT BE CH CY DE DK ES FI FR GB GR IE IT LU MC NL PT SE TR
(OA) BF BJ CF CG CI CM GA GN GQ GW ML MR NE SN TD TG
(AP) GH GM KE LS MW MZ SD SL SZ TZ UG ZM ZW
(EA) AM AZ BY KG KZ MD RU TJ TM
Publication Language: English
Filing Language: English
Fulltext Word Count: 6769
English Abstract
A stereoscopic eye measurement system and method for measurement of corneal characteristics, anterior chamber depth and lens characteristics in a single acquisition. The system and method use a stereoscopic camera configuration comprising center camera (102) and two side cameras (104) and (106) to capture the images of IR pupil, of the intersection of a structured illumination pattern provided by light sources (108) and (109) with the cornea (130) and lens (134), and of the Placido reflection off the cornea. The projection pattern may be a cross pattern, a dot array, a dot + cross pattern, or a starburst pattern. The system uses a large pupil in order to obtain images of the lens. The system uses different focal points to achieve the best images of corneal topography, corneal layering and lens surfaces and a combination of corneal topography, corneal layering, pupil and the lens.

5/3,AB/4 (Item 3 from file: 349)
DIALOG(R)File 349:PCT FULLTEXT

00939869
ADJUSTABLE INTRAOCULAR LENS
LENTILLES INTRA-OCULAIRES AJUSTABLES
Patent Applicant/Assignee:
SARVER & ASSOCIATES, 3425 Savannahs Trail, Merritt Island, FL 32953, US, US (Residence), US (Nationality)
Inventor(s):
SARVER Edwin J , 3425 Savannahs Trail, Merritt Island, FL 32953, US
Legal Representative:
SLAVIN Michael A (agent), McHale & Slavin, P.A., Suite 402, 4440 PGA Blvd., Palm Beach Gardens, FL 33410, US,
Patent and Priority Information (Country, Number, Date):
Patent: WO 200271976 A2-A3 20020919 (WO 0271976)
Application: WO 2002US8047 20020313 (PCT/WO US0208047)
Priority Application: US 2001275220 20010313; US 200299204 20020313

Designated States: AE AG AL AM AT AU AZ BA BB BG BR BY BZ CA CH CN CO CR CU
CZ DE DK DM DZ EE ES FI GB GD GE GH GM HR HU ID IL IN IS JP KE KG KP KR
KZ LC LK LR LS LT LU LV MA MD MG MK MN MW MX MZ NO NZ PL PT RO RU SD SE
SG SI SK SL TJ TM TR TT TZ UA UG UZ VN YU ZA ZW
(EP) AT BE CH CY DE DK ES FI FR GB GR IE IT LU MC NL PT SE TR
(OA) BF BJ CF CG CI CM GA GN GQ GW ML MR NE SN TD TG
(AP) GH GM KE LS MW MZ SD SL SZ TZ UG ZM ZW
(EA) AM AZ BY KG KZ MD RU TJ TM
Publication Language: English
Filing Language: English
Fulltext Word Count: 3738
English Abstract
Improved adjustable intraocular lenses are disclosed, in which the shape of the surface(s) of the lens can be modified post-operatively using manual methods or controlled pulses of laser radiation to achieve improved optical correction.

5/3,AB/6 (Item 5 from file: 349)
DIALOG(R)File 349:PCT FULLTEXT

00832849
COMBINATION ADVANCED CORNEAL TOPOGRAPHY/WAVE FRONT ABERRATION MEASUREMENT
MESURE COMBINEE PERFECTIONNEE D'ABERRATIONS DE FRONT D'ONDE ET DE TOPOGRAPHIE CORNEENNE
Patent Applicant/Assignee:
LASERSIGHT TECHNOLOGIES INC, Suite 140, 3300 University Boulevard, Orlando, FL 32792, US, US (Residence), US (Nationality)
Inventor(s):
SARVER Edwin J , 3425 Savannnahs Trail, Merritt Island, FL 32953, US,
LIU David, 46 Oakdale, Irvine, CA 92604, US
Legal Representative:
BOLLMAN William H (agent), Manelli Denison & Selter Pllc, Suite 700, 2000 M Street, NW, Washington, DC 20036-3307, US,
Patent and Priority Information (Country, Number, Date):
Patent: WO 200166004 A1 20010913 (WO 0166004)
Application: WO 2001US6488 20010301 (PCT/WO US0106488)
Priority Application: US 2000521855 20000309
Designated States: AE AG AL AM AT AU AZ BA BB BG BR BY BZ CA CH CN CR CU CZ
DE DK DM DZ EE ES FI GB GD GE GH GM HR HU ID IL IN IS JP KE KG KP KR KZ
LC LK LR LS LT LU LV MA MD MG MK MN MW MX MZ NO NZ PL PT RO RU SD SE SG
SI SK SL TJ TM TR TT TZ UA UG UZ VN YU ZA ZW
(EP) AT BE CH CY DE DK ES FI FR GB GR IE IT LU MC NL PT SE TR
(OA) BF BJ CF CG CI CM GA GN GW ML MR NE SN TD TG
(AP) GH GM KE LS MW MZ SD SL SZ TZ UG ZW
(EA) AM AZ BY KG KZ MD RU TJ TM
Publication Language: English
Filing Language: English
Fulltext Word Count: 5602
English Abstract
A method for the simultaneous measurement of the anterior and posterior corneal surfaces, corneal thickness, and optical aberrations of the eye surfaces using imaging cameras (c4 and c5) and front view camera (c3). The method employs direct measurements and ray tracing to provide a wide range of measurements for use by the ophthalmic community.

5/3,AB/7 (Item 6 from file: 349)

DIALOG(R)File 349:PCT FULLTEXT

00426705
A METHOD OF CORNEAL ANALYSIS USING A CHECKERED PLACIDO APPARATUS
PROCEDE D'ANALYSE DE LA CORNEE AU MOYEN D'UN DISPOSITIF DE PLACIDO QUADRILLE
Patent Applicant/Assignee:
EYESYS TECHNOLOGIES INC,
Inventor(s):
D'SOUZA Henry M,
SARVER Edwin J ,
WAKIL Youssef S
Patent and Priority Information (Country, Number, Date):
Patent: WO 9817168 A2 19980430
Application: WO 97US19487 19971022 (PCT/WO US9719487)
Priority Application: US 96736348 19961023
Designated States: AL AM AT AU AZ BA BB BG BR BY CA CH CN CU CZ DE DK EE ES FI GB GE GH HU ID IL IS JP KE KG KP KR KZ LC LK LR LS LT LU LV MD MG MK MN MW MX NO NZ PL PT RO RU SD SE SG SI SK SL TJ TM TR TT UA UG UZ VN YU ZW GH KE LS MW SD SZ UG ZW AM AZ BY KG KZ MD RU TJ TM AT BE CH DE DK ES FI FR GB GR IE IT LU MC NL PT SE BF BJ CF CG CI CM GA GN ML MR NE SN TD TG
Publication Language: English
Fulltext Word Count: 15097
English Abstract
A method for analysis of the curvature of the surface of a cornea using a checkered placido comprises projecting the image of the checkered placido onto a patient's cornea, detecting the image of the checkered placido reflected off of the cornea, detecting a plurality of nodal points from the reflected image, determining the mean curvature at a plurality of nodal points and analyzing the mean curvature at a plurality of nodal points in order to produce a graphic display of the estimated actual curvature of the cornea.

5/3,AB/8 (Item 7 from file: 349)
DIALOG(R)File 349:PCT FULLTEXT

00249754
CHECKERED PLACIDO APPARATUS AND METHOD
DISPOSITIF DE PLACIDO QUADRILLE ET PROCEDE CORRESPONDANT
Patent Applicant/Assignee:
EYESYS LABORATORIES,
Inventor(s):
D'SOUZA Henry M,
SARVER Edwin J
Patent and Priority Information (Country, Number, Date):
Patent: WO 9324049 A1 19931209
Application: WO 93US5293 19930602 (PCT/WO US9305293)
Priority Application: US 92891961 19920602
Designated States: AT AU BB BG BR CA CH CZ DE DK ES FI GB HU JP KP KR LK LU MG MN MW NL NO NZ PL PT RO RU SD SE SK UA VN AT BE CH DE DK ES FR GB GR IE IT LU MC NL PT SE BF BJ CF CG CI CM GA GN ML MR NE SN TD TG
Publication Language: English
Fulltext Word Count: 14535
English Abstract
A Multi-Functional Corneal Analysis System for ascertaining the shape of the corneal surface of the eye comprises a CCD camera, frame grabber

board and digital image processing **algorithm** with associated processing circuitry. The CCD camera receives a reflection of a target such as Placido's disc from the surface of the cornea. The CCD image of the reflection of the Placido disc from the corneal surface is captured by the frame grabber board and subjected to digital analysis after treatment in an edge detector. The edge detector reduces the number of data points that must be processed to define the radius of each ring in the reflected Placido disc image. The resultant data are processed to derive surface contour and to provide a display in tabular, graphic or pictorial form of the contour data so generated. The system can be used to design custom contact lens.

5/3,AB/9 (Item 8 from file: 349)
DIALOG(R)File 349:PCT FULLTEXT

00246457
A METHOD AND APPARATUS FOR REPRESENTING AN ABSOLUTE SCALE FOR CORNEAL TOPOGRAPHY
PROCEDE ET APPAREIL DE REPRESENTATION D'UNE ECHELLE ABSOLUE DE TOPOGRAPHIE DE LA CORNEE
Patent Applicant/Assignee:
EYESYS LABORATORIES INC,
Inventor(s):
SARVER Edwin J
Patent and Priority Information (Country, Number, Date):
Patent: WO 9320744 A1 19931028
Application: WO 93US3393 19930412 (PCT/WO US9303393)
Priority Application: US 92676 19920410
Designated States: AT AU BB BG BR CA CH CZ DE DK ES FI GB HU JP KP KR LK LU MG MN MW NL NO NZ PL PT RO RU SD SE SK UA VN AT BE CH DE DK ES FR GB GR IE IT LU MC NL PT SE BF BJ CF CG CI CM GA GN ML MR NE SN TD TG
Publication Language: English
Fulltext Word Count: 4035
English Abstract
An absolute scale for representing isodioptric regions of the cornea is described. The scale uses a combination of colors and patterns to represent a scale that represents a large range of values and has sufficient resolution to be clinically useful. The scale uses a small number of colors combined with patterns so that isodioptric regions are easily discerned. The small number of colors facilitates the representation of a large number of dioptric intervals with a small number of bits.

File 155:MEDLINE(R) 1966-2003/Aug W2
File 5:Biosis Previews(R) 1969-2003/Aug W1
File 73:EMBASE 1974-2003/Aug W1
File 34:SciSearch(R) Cited Ref Sci 1990-2003/Aug W1
File 434:SciSearch(R) Cited Ref Sci 1974-1989/Dec
File 144:Pascal 1973-2003/Aug W1
File 94:JICST-EPlus 1985-2003/Aug W1

Set	Items	Description
S1	8	VISUAL()OPTICS()LAB()3D OR VOL()3D
S2	**6**	**RD (unique items)**

2/6/3 (Item 2 from file: 73)
05348715 EMBASE No: 1993116800
Time of flight 3D MR angiography (MRA) of the renal arteries (RA)
ANGIO IRM DES ARTERES RENALES PAR TEMPS DE **VOL 3D**
1993

2/6/4 (Item 1 from file: 144)
15205813 PASCAL No.: 01-0371389
Comparaison de l'ARM et de l'arteriographie dans le suivi des anevrismes intracraniens traites par GDC a propos de 25 correlations
(Comparison of MRA and angiography in the follow-up of intracranial aneurysms treated with GDC. Report of 25 correlations)
2001

2/6/5 (Item 2 from file: 144)
13284506 PASCAL No.: 98-0007034
Approche multimodalite des bifurcations carotidiennes dans la pathologie atheromateuse
(Multimodal approach to carotid bifurcations in atherosclerosis)
1996

2/6/6 (Item 3 from file: 144)
10866686 PASCAL No.: 93-0376050
Angio IRM des arteres renales par temps de vol 3D
(Time of flight 3D MR angiography of the renal arteries)
1993

2/7/1 (Item 1 from file: 155)
DIALOG(R)File 155:MEDLINE(R)

09167209 20470563 PMID: 11019884
Modeling and predicting visual outcomes with VOL - 3D .
Sarver E J; Applegate R A
Sarver and Associates, Inc., Merritt Island, FL 32953, USA. ejsarver@VOL3D.com
Journal of refractive surgery (Thorofare, N.J. - 1995) (UNITED STATES) Sep-Oct 2000, 16 (5) pS611-6, ISSN 1081-597X Journal Code: 9505927
Contract/Grant No.: R01 EY08520; EY; NEI; R43 EY11681; EY; NEI
Document type: Journal Article; Review; Review, Tutorial
Languages: ENGLISH
Main Citation Owner: NLM
Record type: Completed
(3 Refs.)
Record Date Created: 20010102
Record Date Completed: 20010111

2/7/2 **(Item 1 from file: 73)**
DIALOG(R)File 73:EMBASE

11238114 EMBASE No: 2001252756

Schematic eye models for simulation of patient visual performance

Doshi J.B.; Sarver E.J.; Applegate R.A.
Dr. R.A. Applegate, Department of Ophthalmology, Univ. of Texas Health Science Center, San Antonio, TX 78284-6230 United States
AUTHOR EMAIL: applegate@uthscsa.edu

Journal of Refractive Surgery (J. REFRACTIVE SURG.) (United States) 2001, 17/4 (414-419)
CODEN: JRSUF ISSN: 1081-597X
DOCUMENT TYPE: Journal ; Article
LANGUAGE: ENGLISH SUMMARY LANGUAGE: ENGLISH
NUMBER OF REFERENCES: 10

PURPOSE: To determine if model eyes can simulate the visual performance of normal human eyes under conditions of varying low myopic blur, pupil size, and contrast. METHODS: High and low contrast Bailey-Lovie logMAR visual acuity (VA) of three normal eyes of three subjects were measured for four artificial pupil sizes and ten levels of myopic defocus. Simulated visual acuities were then determined for three model eyes - the Indiana Eye with no spherical aberration, the Indiana Eye with average spherical aberration, and the Kooijman Eye - by generating optically aberrated VA charts for each testing condition using Visual Optics Lab software by Sarver and Associates, Inc, and having the subjects read high resolution printouts of these charts using a 3-mm pupil and optimal spectacle correction. The correlation between real VA and simulated VA was then plotted and a regression line calculated. RESULTS: Slopes for the Indiana Eye, Indiana Eye with spherical aberration, and Kooijman Eye were 0.98, 0.98, and 1.01 for high contrast, and 0.92, 0.67, and 0.75 for low contrast, respectively. The rSUP2 values were 0.73, 0.74, and 0.77, for high contrast, and 0.69, 0.40, and 0.50 for low contrast, respectively. Under low contrast conditions the Indiana Eye VA was significantly closer to the real VA than that of the other two models (P<.0003). CONCLUSION: Visual performance can be simulated by eye models. The simple single surface Indiana Eye with no spherical aberration best modeled both high and low contrast visual acuity.

File 35:Dissertation Abs Online 1861-2003/Jul
File 65:Inside Conferences 1993-2003/Aug W2
File 144:Pascal 1973-2003/Aug W1
File 399:CA SEARCH(R) 1967-2003/UD=13907

Set	Items	Description
S1	10	VISUAL()OPTICS()LAB?()3D OR VOL()3D
S2	**10**	**Sort S1/ALL/PY,D**

2/6/2 (Item 2 from file: 399)

Theoretical study for partial molar volume of amino acids and polypeptides by the three-dimensional reference interaction site model

2/6/4 (Item 4 from file: 399)

3D numerical analysis on electromagnetic and fluid dynamic phenomena in a soft contact electromagnetic slab caster

2/6/5 (Item 5 from file: 399)

Printer and printing suitable for small-volume 3D printing

2/6/6 (Item 6 from file: 144)
13284506 PASCAL No.: 98-0007034
Approche multimodalite des bifurcations carotidiennes dans la pathologie atheromateuse
(Multimodal approach to carotid bifurcations in atherosclerosis)
1996

2/6/7 (Item 7 from file: 399)

Bulk properties of aqueous solutions of 3d metal perchlorates in relation to hydration of the corresponding cations

2/6/8 (Item 8 from file: 35)
01420437 ORDER NO: AADAA-IC415770
MAGNETIC RESONANCE ANGIOGRAPHY OF SEVERE CAROTID STENOSES: CORRELATIONS WITH DOPPLER ULTRASONOGRAPHY
Original Title: ANGIOGRAPHIE PAR RESONANCE MAGNETIQUE DES STENOSES CAROTIDIENNES SEVERES: CORRELATIONS A L'ECHO-DOPPLER
Year: 1994

2/6/9 (Item 9 from file: 399)

A large volume 3D imaging gas scintillation counter with CsI-based wire chamber readout

2/6/10 (Item 10 from file: 144)
10866686 PASCAL No.: 93-0376050
Angio IRM des arteres renales par temps de vol 3D
(Time of flight 3D MR angiography of the renal arteries)
1993

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File 155:MEDLINE(R) 1966-2003/Aug W2
File   5:Biosis Previews(R) 1969-2003/Aug W1
File  73:EMBASE 1974-2003/Aug W1
File  34:SciSearch(R) Cited Ref Sci 1990-2003/Aug W1
File 434:SciSearch(R) Cited Ref Sci 1974-1989/Dec
Set     Items   Description
S1         50   AU='SARVER E' OR AU='SARVER E J' OR AU='SARVER E.J.' OR AU-
             ='SARVER EDWIN J' OR AU='SARVER EJ'
S2     380967   ALGORITHM?
S3     178973   VISION
S4          1   S1 AND S2 AND S3
S5         49   S1 NOT S4
S6         24   S5/2001 OR S5/2002 OR S5/2003
S7         25   S5 NOT S6
S8         15   RD (unique items) [duplicates]
S9          0   S8 AND S2:S3
```

4/7/1 (Item 1 from file: 73)
DIALOG(R)File 73:EMBASE

11667697 EMBASE No: 2002240364

Inattention to nonsuperimposable midline symmetry causes wavefront analysis error

Smolek M.K.; Klyce S.D.; **Sarver E.J.**
Dr. M.K. Smolek, LSU Eye Center, 2020 Gravier St, New Orleans, LA 70112 United States
AUTHOR EMAIL: msmole@lsuhsc.edu
Archives of Ophthalmology (ARCH. OPHTHALMOL.) (United States) 2002, 120/4 (439-447)
CODEN: AROPA ISSN: 0003-9950
DOCUMENT TYPE: Journal ; Article
LANGUAGE: ENGLISH SUMMARY LANGUAGE: ENGLISH
NUMBER OF REFERENCES: 10
Background: The nonsuperimposable mirror-image symmetry of the body (enantiomorphism) is reflected in the wavefront error maps of eyes. Averaging the wavefront errors of right and left eyes has the potential to adversely affect correlations made between wavefront error and visual acuity or other factors. Not only are the results of past studies using Zernike terms suspected of being invalid, there is concern about possible errors in the **algorithms** used to create customized corneal ablations. Objective: To compare the results of analysis with and without correction for enantiomorphism. Methods: Fourteen TMS-1 corneal topographic maps from 7 patients having with-the-rule astigmatism in both corneas were selected for Zernike decomposition to 45 terms. The maps were distributed among 3 groups: 7 right eye maps, 7 left eye maps, and 7 left eye maps in which the topography was transposed about the vertical axial to correct for enantiomorphism (left eye-corrected). The wavefront error difference between the right and left eyes was compared with the difference between the right eyes and the left eyes in which enantiomorphism was corrected (right eye vs left eye-corrected). The left eye wavefront error was then compared with the left eye wavefront error after correction (left eye vs left eye-corrected). Results: Correcting for enantiomorphism produced a statisticially significant difference in the first 5 radial orders of Zernike terms (P=.02). Of the 45 Zernike terms analyzed, 7 terms were significantly different at the P<.05 level in the right eye vs left eye category, compared with 4 terms in the right eye vs left eye-corrected

category. Eleven terms were significantly different at the $P<.05$ level in the left eye vs left eye-corrected category. Conclusions: Correcting for enantiomorphism makes the Zernike terms in right and left eyes appear more similar. Failure to correct for enantiomorphism causes certain terms to cancel each other when averaged across right and left eyes. Wavefront error studies that do not consider enantiomorphism, including those used to adjust laser surgical nomograms, will introduce significant errors to certain Zernike terms.

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File 155:MEDLINE(R) 1966-2003/Aug W2
File   5:Biosis Previews(R) 1969-2003/Aug W1
File  73:EMBASE 1974-2003/Aug W1
File  34:SciSearch(R) Cited Ref Sci 1990-2003/Aug W1
File 434:SciSearch(R) Cited Ref Sci 1974-1989/Dec
Set     Items   Description
S1         32   E3OR E4 OR AU='SARVER E.J.' OR AU='SARVER EDWIN J' OR AU='-
             SARVER EJ'
S2         20   S1/2001:2003
S3         12   S1 NOT S2
S4         10   RD (unique items)
S5         20   S2 NOT S3
S6          9   RD (unique items)
```

4/7/1 (Item 1 from file: 5)
DIALOG(R)File 5:Biosis Previews(R)

13006456 BIOSIS NO.: 200100213605
Device and method for mapping the topography of an eye using elevation measurements in combination with slope measurements.
AUTHOR: **Sarver Edwin J** ; Broadus Charles R
JOURNAL: Official Gazette of the United States Patent and Trademark Office
Patents 1238 (3):pNo Pagination Sep. 19, 2000
MEDIUM: e-file
ISSN: 0098-1133
DOCUMENT TYPE: Patent
RECORD TYPE: Abstract
LANGUAGE: English
ABSTRACT: In an inventive method for mapping the topography of an eye, elevation measurements of the eye are collected using a slit beam diffuse reflection system, such as an ORBSCAN.TM. device. An approximating b-spline surface is then fitted to the elevation measurements. Slope measurements of the eye are collected using a Placido-based reflective system, but the slope measurements are referenced to points on the b-spline surface, rather than to points approximated using the conventional constant curvature method, so the measurements have substantially improved accuracy. The elevation and slope measurements are then blended using weighted least squares fitting techniques. A new b-spline surface is fitted to the blended measurements, with the new surface having substantially improved accuracy in depicting the actual topography of the eye as a result of the elevation-improved accuracy of the slope measurements.

4/7/2 (Item 2 from file: 5)
DIALOG(R)File 5:Biosis Previews(R)

12253642 BIOSIS NO.: 200000007144
Multi-camera corneal analysis system.
AUTHOR: **Sarver Edwin J** (a); D'Souza Henry
AUTHOR ADDRESS: (a)The Center for Health and Social Policy, Merritt Island, FL**USA
JOURNAL: Official Gazette of the United States Patent and Trademark Office
Patents 1226 (2):pNo pagination Sep. 14, 1999
ISSN: 0098-1133
DOCUMENT TYPE: Patent
RECORD TYPE: Citation

LANGUAGE: English

4/7/3 (Item 1 from file: 73)
DIALOG(R)File 73:EMBASE

10880270 EMBASE No: 2000364895
Modeling and predicting visual outcomes with VOL-3D
Sarver E.J. ; Applegate R.A.
Dr. E.J. Sarver, Sarver and Associates, Inc., 3425 Savannahs Trail, Merritt Island, FL 32953 United States
AUTHOR EMAIL: ejsarver@VOL3D.com
Journal of Refractive Surgery (J. REFRACTIVE SURG.) (United States) 2000, 16/5 (S611-S616)
CODEN: JRSUF ISSN: 1081-597X
DOCUMENT TYPE: Journal; Conference Paper
LANGUAGE: ENGLISH
NUMBER OF REFERENCES: 3

4/7/4 (Item 1 from file: 34)
DIALOG(R)File 34:SciSearch(R) Cited Ref Sci

08778417 Genuine Article#: 300HF Number of References: 0
Title: Pupil position and retinal image quality
Author(s): Doshi JB; **Sarver EJ** ; Applegate RA
Corporate Source: UNIV TEXAS,HLTH SCI CTR/SAN ANTONIO//TX/; SARVER & ASSOC INC,/MERRITT ISL//FL/
Journal: INVESTIGATIVE OPHTHALMOLOGY & VISUAL SCIENCE, 2000, V41, N4,S (MAR 15), P68514-68514
ISSN: 0146-0404 Publication date: 20000315
Publisher: ASSOC RESEARCH VISION OPHTHALMOLOGY INC, 9650 ROCKVILLE PIKE, BETHESDA, MD 20814-3998
Language: English Document Type: MEETING ABSTRACT

4/7/5 (Item 2 from file: 34)
DIALOG(R)File 34:SciSearch(R) Cited Ref Sci

07613819 Genuine Article#: 178MF Number of References: 0
Title: B-spline representation of corneal topography data for near real time optical ray tracing
Author(s): **Sarver EJ** ; Applegate RA
Corporate Source: SARVER & ASSOCIATES INC,/MERRITT ISL//FL/; UNIV TEXAS,HLTH SCI CTR, DEPT OPHTHALMOL/SAN ANTONIO//TX/78284
Journal: INVESTIGATIVE OPHTHALMOLOGY & VISUAL SCIENCE, 1999, V40, N4 (MAR 15), P932-932
ISSN: 0146-0404 Publication date: 19990315
Publisher: ASSOC RESEARCH VISION OPHTHALMOLOGY INC, 9650 ROCKVILLE PIKE, BETHESDA, MD 20814-3998
Language: English Document Type: MEETING ABSTRACT

4/7/6 (Item 3 from file: 34)
DIALOG(R)File 34:SciSearch(R) Cited Ref Sci

07613097 Genuine Article#: 178MF Number of References: 0
Title: Simulated visual performance: An objective comparison of schematic eye models
Author(s): Doshi JB; **Sarver EJ** ; Nesmith WR; Applegate RA

Corporate Source: UNIV TEXAS,HLTH SCI CTR/SAN ANTONIO//TX/; SARVER & ASSOC INC,/MERRITT ISL//FL/
Journal: INVESTIGATIVE OPHTHALMOLOGY & VISUAL SCIENCE, 1999, V40, N4 (MAR 15), P9169-9169
ISSN: 0146-0404 Publication date: 19990315
Publisher: ASSOC RESEARCH VISION OPHTHALMOLOGY INC, 9650 ROCKVILLE PIKE, BETHESDA, MD 20814-3998
Language: English Document Type: MEETING ABSTRACT

4/7/7 (Item 4 from file: 34)
DIALOG(R)File 34:SciSearch(R) Cited Ref Sci
(c) 2003 Inst for Sci Info. All rts. reserv.
07612928 Genuine Article#: 178MF Number of References: 0
Title: Modeling visual performance in clinical eyes
Author(s): Applegate RA; **Sarver EJ**
Corporate Source: UNIV TEXAS,HLTH SCI CTR, DEPT OPHTHALMOL/SAN ANTONIO//TX/78284; SARVER & ASSOC INC,/MERRITT ISL//FL/
Journal: INVESTIGATIVE OPHTHALMOLOGY & VISUAL SCIENCE, 1999, V40, N4 (MAR 15), P40-40
ISSN: 0146-0404 Publication date: 19990315
Publisher: ASSOC RESEARCH VISION OPHTHALMOLOGY INC, 9650 ROCKVILLE PIKE, BETHESDA, MD 20814-3998
Language: English Document Type: MEETING ABSTRACT

4/7/8 (Item 5 from file: 34)
DIALOG(R)File 34:SciSearch(R) Cited Ref Sci
(c) 2003 Inst for Sci Info. All rts. reserv.
03051641 Genuine Article#: MZ585 Number of References: 0
Title: A HYBRID TRANSFORM FOR USE WITH CORNEAL TOPOGRAPHY
Author(s): **SARVER EJ** ; PADRICK TD; GADKARI S; SOPER B
Corporate Source: EYESYS TECHNOL INC/HOUSTON//TX/00000
Journal: INVESTIGATIVE OPHTHALMOLOGY & VISUAL SCIENCE, 1994, V35, N4 (MAR 15), P2107
ISSN: 0146-0404
Language: ENGLISH Document Type: MEETING ABSTRACT

4/7/9 (Item 6 from file: 34)
DIALOG(R)File 34:SciSearch(R) Cited Ref Sci
(c) 2003 Inst for Sci Info. All rts. reserv.
03051640 Genuine Article#: MZ585 Number of References: 0
Title: A POLAR GRID DESIGN FOR CORNEAL TOPOGRAPHY
Author(s): PADRICK TD; **SARVER EJ** ; GOLLA B
Corporate Source: EYESYS TECHNOL INC/HOUSTON//TX/00000
Journal: INVESTIGATIVE OPHTHALMOLOGY & VISUAL SCIENCE, 1994, V35, N4 (MAR 15), P2107
ISSN: 0146-0404
Language: ENGLISH Document Type: MEETING ABSTRACT

4/7/10 (Item 7 from file: 34)
DIALOG(R)File 34:SciSearch(R) Cited Ref Sci
(c) 2003 Inst for Sci Info. All rts. reserv.
02329882 Genuine Article#: KT893 Number of References: 0
Title: ERROR ANALYSIS OF CORNEAL TOPOGRAPHY MEASUREMENTS FOR ASPERIC SURFACES
Author(s): **SARVER EJ** ; PADRICK TD
Corporate Source: EYESYS LABS/HOUSTON//TX/77055

Journal: INVESTIGATIVE OPHTHALMOLOGY & VISUAL SCIENCE, 1993, V34, N4 (MAR 15), P1252
ISSN: 0146-0404
Language: ENGLISH Document Type: MEETING ABSTRACT

6/7/1 (Item 1 from file: 155)
DIALOG(R)File 155:MEDLINE(R)

15197441 22780899 PMID: 12899469
Image quality in myopic eyes corrected with laser in situ keratomileusis and phakic intraocular lens.
Sarver Edwin J ; Sanders Donald R; Vukich John A
Sarver and Associates, Inc., Celebration, FL 34747, USA. ejsarver@aol.com
Journal of refractive surgery (Thorofare, N.J. - 1995) (United States) Jul-Aug **2003** , 19 (4) p397-404, ISSN 1081-597X Journal Code: 9505927
Document type: Journal Article
Languages: ENGLISH
Main Citation Owner: NLM
Record type: In Process
PURPOSE: To compare image quality due to higher-order aberrations following laser in situ keratomileusis (LASIK) or implantation of phakic intraocular lens (PIOL) to correct high myopia. METHODS: Postoperative wavefront examinations, normalized to a pupil size of 5.5 mm, were obtained for 19 LASIK and 20 PIOL eyes for the same surgeon over the same time period. Higher-order aberrations and simulated retinal images were compared. RESULTS: For this small sample, the LASIK eyes yielded an average three times more spherical aberration and two times more coma than PIOL eyes. The effects of these differences were visualized using the simulated retinal images. CONCLUSION: Spherical aberration and coma are the major differences between postoperative LASIK and PIOL higher-order aberrations, and simulated retinal images can be used to visualize these effects.
Record Date Created: 20030805

6/7/2 (Item 2 from file: 155)
DIALOG(R)File 155:MEDLINE(R)

14522084 22485047 PMID: 12597324
Visual acuity as a function of Zernike mode and level of root mean square error.
Applegate Raymond A; Ballentine Charles; Gross Hillery; **Sarver Edwin J** ; Sarver Charlene A
College of Optometry, University of Houston, Houston, Texas 77204-2020, USA. rapplegate@uh.edu
Optometry and vision science - official publication of the American Academy of Optometry (United States) Feb **2003** , 80 (2) p97-105, ISSN 1040-5488 Journal Code: 8904931
Contract/Grant No.: R01 08520; PHS; R44 EY 11681; EY; NEI
Document type: Journal Article
Languages: ENGLISH
Main Citation Owner: NLM
Record type: Completed
BACKGROUND: The coefficients of normalized Zernike expansion are orthogonal and reflect the relative contribution of each mode to the total root mean square (RMS) wavefront error. The relationship between the level of RMS wavefront error within a mode and its effect on visual performance is unknown. PURPOSE: To determine for various levels of RMS wavefront error

how each mode of the normalized Zernike expansion for the second, third, and fourth orders affect high- and low-contrast acuity. METHODS: Three healthy optimally corrected cyclopleged subjects read aberrated and unaberrated high- and low-contrast logarithm of the minimum angle of resolution acuity charts monocularly through a 3-mm artificial pupil. Acuity was defined by the total number of letters read correctly up to the fifth miss. Aberrated and unaberrated charts were generated using a program called CTView. Six levels of RMS wavefront error were used (0.00, 0.05, 0.10, 0.15, 0.20, and 0.25 microm). Each level of RMS error was loaded into each mode of the second, third, and fourth radial orders individually for a total of 72 charts. Data were normalized by subject, and the normalized data were averaged across subjects. RESULTS: Across modes and within each mode as the level of RMS wavefront error increased above 0.05 microm of RMS wavefront error, visual acuity decreased in a linear fashion. Slopes of the linear fits varied depending on the mode. Modes near the center of the Zernike pyramid had steeper slopes than those near the edge. CONCLUSIONS: Increasing the RMS error within any single mode of the normalized Zernike expansion decreases visual acuity in a linear fashion. The slope of the best fitting linear equation varies with Zernike mode. Slopes near the center of the Zernike pyramid are steeper than those near the edge. Although the normalized Zernike expansion parcels RMS error orthogonally, the resulting effects on visual performance as measured by visual acuity are not orthogonal. New metrics of the combined effects of the optical and the neural transfer functions that are predictive of visual performance need to be developed.

Record Date Created: 20030224
Record Date Completed: 20030304

6/7/3 (Item 3 from file: 155)
DIALOG(R)File 155:MEDLINE(R)

14377120 22248109 PMID: 12361157

Are all aberrations equal?

Applegate Raymond A; **Sarver Edwin J** ; Khemsara Vic; et al
College of Optometry, University of Houston, TX 77204-2020, USA. rapplegate@uh.edu

Journal of refractive surgery (Thorofare, N.J. - 1995) (United States) Sep-Oct **2002** , 18 (5) pS556-62, ISSN 1081-597X Journal Code: 9505927
Contract/Grant No.: R01 08520; PHS; R44 EY 11681; EY; NEI; +
Document type: Journal Article
Languages: ENGLISH
Main Citation Owner: NLM
Record type: Completed

PURPOSE: To determine for a fixed RMS error (25 microm, over a 6-mm pupil) how each mode of the normalized Zernike polynomial (second through the fourth radial order) affects high and low contrast logMAR visual acuity. METHODS: Three healthy volunteers served as subjects. CTView was used to generate optically aberrated logMAR charts. Accommodation was paralyzed and pupils dilated. The foveal achromatic axis of the eye was aligned to a 3-mm pupil and the eye was optimally refracted. Aberrated acuity charts were read until five letters were missed. Data were normalized for each subject to the acuity obtained by reading unaberrated charts and plotted as letters lost as a function of Zernike mode. RESULTS: Defocus (Z2(0)) decreased letter acuity more than astigmatism (Z2(2), Z2(-2)). Coma (Z3(1), Z3(-1)) decreased acuity more than trefoil (Z3(3), Z3(-3)). Spherical aberration (Z4(0)) and secondary astigmatism (Z2(2),

Z4(-2)) decreased acuity much more than quadrafoil (Z4(4), Z4(-4)). CONCLUSIONS: 1. For an equal amount of RMS error not all coefficients of the Zernike polynomial induce equivalent losses in high and low contrast logMAR acuity. 2. Wavefront error concentrated near the center of the pyramid adversely affects visual acuity more than modes near the edge of the pyramid. 3. Large changes in chart appearance are not reflected in equally large decreases in visual performance (ie, subjects could correctly identify highly aberrated letters). 4. Interactions between modes complicate weighting each Zernike mode for visual impact.

Record Date Created: 20021003
Record Date Completed: 20030128

6/7/4 (Item 4 from file: 155)

DIALOG(R)File 155:MEDLINE(R)

10003594 21932039 PMID: 11934317

Inattention to nonsuperimposable midline symmetry causes wavefront analysis error.

Smolek Michael K; Klyce Stephen D; **Sarver Edwin J**
LSU Eye Center, 2020 Gravier St, Suite B, New Orleans, LA 70112, USA. msmole@lsuhsc.edu
Archives of ophthalmology (United States) Apr **2002** , 120 (4) p439-47, ISSN 0003-9950 Journal Code: 7706534
Contract/Grant No.: P30 EY 02377; EY; NEI; R01 EY 03311; EY; NEI
Document type: Journal Article
Languages: ENGLISH
Main Citation Owner: NLM
Record type: Completed

BACKGROUND: The nonsuperimposable mirror-image symmetry of the body (enantiomorphism) is reflected in the wavefront error maps of eyes. Averaging the wavefront errors of right and left eyes has the potential to adversely affect correlations made between wavefront error and visual acuity or other factors. Not only are the results of past studies using Zernike terms suspected of being invalid, there is concern about possible errors in the algorithms used to create customized corneal ablations. OBJECTIVE: To compare the results of analysis with and without correction for enantiomorphism. METHODS: Fourteen TMS-1 corneal topographic maps from 7 patients having with-the-rule astigmatism in both corneas were selected for Zernike decomposition to 45 terms. The maps were distributed among 3 groups: 7 right eye maps, 7 left eye maps, and 7 left eye maps in which the topography was transposed about the vertical axial to correct for enantiomorphism (left eye-corrected). The wavefront error difference between the right and left eyes was compared with the difference between the right eyes and the left eyes in which enantiomorphism was corrected (right eye vs left eye-corrected). The left eye wavefront error was then compared with the left eye wavefront error after correction (left eye vs left eye-corrected). RESULTS: Correcting for enantiomorphism produced a statisticially significant difference in the first 5 radial orders of Zernike terms (P=.02). Of the 45 Zernike terms analyzed, 7 terms were significantly different at the P<.05 level in the right eye vs left eye category, compared with 4 terms in the right eye vs left eye-corrected category. Eleven terms were significantly different at the P<.05 level in the left eye vs left eye-corrected category. CONCLUSIONS: Correcting for enantiomorphism makes the Zernike terms in right and left eyes appear more similar. Failure to correct for enantiomorphism causes certain terms to cancel each other when averaged across right and left eyes. Wavefront error

studies that do not consider enantiomorphism, including those used to adjust laser surgical nomograms, will introduce significant errors to certain Zernike terms.
Record Date Created: 20020405
Record Date Completed: 20020418

6/7/5 (Item 1 from file: 5)
DIALOG(R)File 5:Biosis Previews(R)

13300568 BIOSIS NO.: 200100507717
Combination advanced corneal topography/wave front aberration measurement.
AUTHOR: **Sarver Edwin J** ; Liu David(a
AUTHOR ADDRESS: (a)Irvine, CA**USA
JOURNAL: Official Gazette of the United States Patent and Trademark Office Patents 1246 (4):pNo Pagination May 22, **2001**
MEDIUM: e-file
ISSN: 0098-1133
DOCUMENT TYPE: Patent
RECORD TYPE: Abstract
LANGUAGE: English
ABSTRACT: A method for the simultaneous measurement of the anterior and posterior corneal surfaces, corneal thickness, and optical aberrations of the eye. The method employs direct measurements and ray tracing to provide a wide range of measurements for use by the ophthalmic community.

6/7/6 (Item 2 from file: 5)
DIALOG(R)File 5:Biosis Previews(R)

13249368 BIOSIS NO.: 200100456517
Method of corneal analysis using a checkered placido apparatus.
AUTHOR: D'Souza Henry M(a); **Sarver Edwin J** ; Wakil Youssef S
AUTHOR ADDRESS: (a)Cypress, TX**USA
JOURNAL: Official Gazette of the United States Patent and Trademark Office Patents 1245 (2):pNo Pagination Apr. 10, **2001**
MEDIUM: e-file
ISSN: 0098-1133
DOCUMENT TYPE: Patent
RECORD TYPE: Abstract
LANGUAGE: English
ABSTRACT: A method for analysis of the curvature of the surface of a cornea using a checkered placido comprises, projecting the image of the checkered placido onto a patient's cornea, detecting the image of the checkered placido reflected off of the cornea, detecting a plurality of nodal points from the reflected image, determining the mean curvature at a plurality of nodal points and analyzing the mean curvature at a plurality of nodal points in order to produce a graphic display of the estimated actual curvature of the cornea.

6/7/7 (Item 3 from file: 5)
DIALOG(R)File 5:Biosis Previews(R)

13181969 BIOSIS NO.: 200100389118
Device and method for mapping the topography of an eye using elevation measurements in combination with slope measurements.
AUTHOR: **Sarver Edwin J** ; Broadus Charles R
JOURNAL: Official Gazette of the United States Patent and Trademark Office

Patents 1248 (2):pNo Pagination July 10, **2001**
MEDIUM: e-file
ISSN: 0098-1133
DOCUMENT TYPE: Patent
RECORD TYPE: Abstract
LANGUAGE: English

ABSTRACT: In an inventive method for mapping the topography of an eye, elevation measurements of the eye are collected using a slit beam diffuse reflection system, such as an ORBSCAN.TM. device. An approximating b-spline surface is then fitted to the elevation measurements. Slope measurements of the eye are collected using a Placido-based reflective system, but the slope measurements are referenced to points on the b-spline surface, rather than to points approximated using the conventional constant curvature method, so the measurements have substantially improved accuracy. The elevation and slope measurements are then blended using weighted least squares fitting techniques. A new b-spline surface is fitted to the blended measurements, with the new surface having substantially improved accuracy in depicting the actual topography of the eye as a result of the elevation-improved accuracy of the slope measurements.

6/7/8 (Item 1 from file: 73)
DIALOG(R)File 73:EMBASE

11322556 EMBASE No: 2001337181
Erratum: Schematic eye models for simulation of patient visual performance (Journal of Refractive Surgery (2001) 17 (414-419))
Doshi J.B.; **Sarver E.J.** ; Applegate R.A.
Journal of Refractive Surgery (J. REFRACTIVE SURG.) (United States)
2001, 17/5 (498-499)
CODEN: JRSUF ISSN: 1081-597X
DOCUMENT TYPE: Journal ; Erratum
LANGUAGE: ENGLISH

6/7/9 (Item 2 from file: 73)
DIALOG(R)File 73:EMBASE

11238114 EMBASE No: 2001252756
Schematic eye models for simulation of patient visual performance
Doshi J.B.; **Sarver E.J.** ; Applegate R.A.
Dr. R.A. Applegate, Department of Ophthalmology, Univ. of Texas Health Science Center, San Antonio, TX 78284-6230 United States
AUTHOR EMAIL: applegate@uthscsa.edu
Journal of Refractive Surgery (J. REFRACTIVE SURG.) (United States)
2001, 17/4 (414-419)
CODEN: JRSUF ISSN: 1081-597X
DOCUMENT TYPE: Journal ; Article
LANGUAGE: ENGLISH SUMMARY LANGUAGE: ENGLISH
NUMBER OF REFERENCES: 10

PURPOSE: To determine if model eyes can simulate the visual performance of normal human eyes under conditions of varying low myopic blur, pupil size, and contrast. METHODS: High and low contrast Bailey-Lovie logMAR visual acuity (VA) of three normal eyes of three subjects were measured for four artificial pupil sizes and ten levels of myopic defocus. Simulated visual acuities were then determined for three model eyes - the Indiana Eye with no spherical aberration, the Indiana Eye with average spherical

aberration, and the Kooijman Eye - by generating optically aberrated VA charts for each testing condition using Visual Optics Lab software by Sarver and Associates, Inc, and having the subjects read high resolution printouts of these charts using a 3-mm pupil and optimal spectacle correction. The correlation between real VA and simulated VA was then plotted and a regression line calculated. RESULTS: Slopes for the Indiana Eye, Indiana Eye with spherical aberration, and Kooijman Eye were 0.98, 0.98, and 1.01 for high contrast, and 0.92, 0.67, and 0.75 for low contrast, respectively. The rSUP2 values were 0.73, 0.74, and 0.77, for high contrast, and 0.69, 0.40, and 0.50 for low contrast, respectively. Under low contrast conditions the Indiana Eye VA was significantly closer to the real VA than that of the other two models (P<.0003). CONCLUSION: Visual performance can be simulated by eye models. The simple single surface Indiana Eye with no spherical aberration best modeled both high and low contrast visual acuity.

File 155:MEDLINE(R) 1966-2003/Aug W2
File 5:Biosis Previews(R) 1969-2003/Aug W1
File 73:EMBASE 1974-2003/Aug W1
File 34:SciSearch(R) Cited Ref Sci 1990-2003/Aug W1
File 434:SciSearch(R) Cited Ref Sci 1974-1989/Dec

Set	Items	Description
S1	18	AU='SARVER E' OR AU='SARVER E J'
S2	17	RD (unique items)
S3	**5**	**S2/2001:2003**
S4	12	S2 NOT S3
S5	**12**	**Sort S4/ALL/PY,D [duplicates]**

3/7/2 (Item 1 from file: 5)
DIALOG(R)File 5:Biosis Previews(R)

14171351 BIOSIS NO.: 200300165380
Simulation of Adaptive Algorithm to Predict LASIK Postoperative Wavefront Aberrations.
AUTHOR: **Sarver E J** (a); Applegate R A; Sarver C A(a
AUTHOR ADDRESS: (a)Sarver and Associates, Inc., Merritt Island, FL, USA** USA
JOURNAL: ARVO Annual Meeting Abstract Search and Program Planner 2002p Abstract No 3948 **2002**
MEDIUM: cd-rom
CONFERENCE/MEETING: Annual Meeting of the Association For Research in Vision and Ophthalmology Fort Lauderdale, Florida, USA May 05-10, 2002
RECORD TYPE: Abstract
LANGUAGE: English
ABSTRACT: Purpose: To develop an adaptive algorithm for the prediction of LASIK postoperative wavefront aberrations. Methods: A simulated database of 1000 LASIK cases was generated consisting of (1) preoperative corneal topography, (2) preoperative wavefront aberrations, and (3) postoperative wavefront aberrations. The simulated corneal surface consisted of samples of a biconic with apical radii Rx and Ry (mean=7.8 mm, sd=0.2 mm) and conic coefficients Px and Py (mean=0.75, sd=0.1). The simulated preoperative wavefront aberration was generated for a spectacle correction S (mean=-4.0 D, sd=1.0 D). The ablation plan was designed to yield a spherical cornea computed according to paraxial optics. The simulated postoperative wavefront aberration was computed where the cornea had a constant postoperative oblate shape factor surprise

simulated by conic coefficient P=1.1 and a constant postoperative spectacle correction of -0.5 D. A ray transfer element (RTE) software module was developed which provides both a means to generate an optical model that is consistent with exam data and a means to adapt the modeling to past surgical procedures so that prediction of postoperative outcomes is improved for future surgeries. The algorithm consisted of six steps: 1. Given preoperative corneal surface and wavefront, compute optical model for the remainder of the eye using an RTE. 2. Given preoperative corneal surface and wavefront, compute desired postoperative corneal surface. 3. Given desired postoperative corneal surface and RTE from step 1, compute predicted postoperative wavefront. 4. Given actual postoperative wavefront and the desired postoperative corneal surface, compute an RTE to represent the remainder of the eye. 5. Find the difference between the RTE calculated in step 1 and the RTE calculated in step 4. 6. Find a weighted mean of the differences computed in step 5 and use to correct the RTE used in step 3 of future cases. Results: The mean error in the predicted postoperative spectacle spherical equivalent (SEQ) for the 1000 simulated cases was 0.00003 D. The algorithm was able to predict 90.0% of the RMS higher-order wavefront aberrations (third-order and above). The mean computation time per case was 0.36 seconds on a 1.8 GHz PC. Conclusion: Our approach provides a means to predict LASIK postoperative wavefront aberrations. The results indicate the algorithm works well for simulated cases and further study with a large clinical LASIK data set is warranted. In addition, the near real-time computation times indicate that the algorithm may be suitable for clinical applications.

3/7/3 (Item 2 from file: 5)
DIALOG(R)File 5:Biosis Previews(R)

14160377 BIOSIS NO.: 200300154406
Quantifying Visual Quality: When is it Bad?.
AUTHOR: Gross H E(a); Ballentine C S; **Sarver E J**; Sarver C A; Applegate R A
AUTHOR ADDRESS: (a)College of Optometry, Univ of Houston, Houston, TX, USA
JOURNAL: ARVO Annual Meeting Abstract Search and Program Planner 2002p Abstract No 2036 **2002**
MEDIUM: cd-rom
CONFERENCE/MEETING: Annual Meeting of the Association For Research in Vision and Ophthalmology Fort Lauderdale, Florida, USA May 05-10, 2002
RECORD TYPE: Abstract
LANGUAGE: English
ABSTRACT: Background: Although an acuity chart may be readable after refractive surgery, the individual may not be happy with the visual quality. Purpose: To determine the level of aberration at which the normal individual feels the quality of vision is unacceptable. Method: 3 healthy volunteers with 20/16 or better acuity served as subjects. CTViewTM (Sarver and Associates, Inc.) was used to generate high-resolution simulated retinal images of aberrated high contrast log MAR charts having RMS error levels (0.0, 0.05, 0.10, 0.15, 0.20, and 0.25mu over a 6mm pupil) for each Zernike coefficients 3 - 14. Equivalent defocus ranged from 0.00 to 0.19 diopters. Subjects were dilated with 1% tropicamide. The foveal achromatic axis of the eye was aligned to a 3 mm pupil using an achromatic alignicator and a bite bar mounted to a 3 dimensional translator. Then the eye was optimally refracted for the 10' test distance (i.e., eyes are close to, if not, diffraction limited when optimally corrected and viewing through a 3 mm pupil diameter). Subjects

were asked to rank the charts using a 10 point Likert scale to the first decimal place with 10.0 excellent, 7.5 good, 5.0 acceptable, 2.5 bad, and 0.0 unacceptable. A 0-aberration chart was used for refraction, and as a reference. Subjects were told to consider the 0-aberration chart a 10.0, the best their vision could be. There were three counter balanced trials for each set, with six sets. Between each set the "10.0" reference chart was shown again. Results: Subjects consistently ranked the charts with 0.25mu RMS error as unacceptable. 0.20mu ranked below 2.5 (below bad). Friedman's chi square test for level of aberration found a significant difference between levels, p < .0001. Nemenyi's post hoc test found that 0.25mu of aberration was significantly worse than 0.10, 0.05, and 0.0mu. 0.20mu was significantly worse than 0.10, 0.05, and 0.0mu. 0.15mu was significantly worse than 0.05 and 0.0mu. 0.05mu was no different than 0.0mu. Conclusion: This data suggest that refractive surgery should not induce more than 0.10mu of RMS error regardless of how readable the letters.

3/7/4 (Item 3 from file: 5)
DIALOG(R)File 5:Biosis Previews(R)

14160376 BIOSIS NO.: 200300154405
Are all Aberrations Equal?.
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JOURNAL: ARVO Annual Meeting Abstract Search and Program Planner 2002p Abstract No 2035 **2002**
MEDIUM: cd-rom
CONFERENCE/MEETING: Annual Meeting of the Association For Research in Vision and Ophthalmology Fort Lauderdale, Florida, USA May 05-10, 2002
RECORD TYPE: Abstract
LANGUAGE: English
ABSTRACT: Purpose: To determine which aberrations most affect high and low contrast acuity. Methods: 3 healthy volunteers with 20/16 or better acuity served as subjects. CTViewTM generated optically aberrated log MAR charts for a fixed level of aberration (25 microns RMS) for Zernike mode 3 - 14 . Accommodation was paralyzed and pupils dilated with 1% cyclopentolate hydrochloride. The foveal achromatic axis of the eye was aligned to a 3 mm pupil using an achromatic alignicator and a bite bar mounted to a 3 dimensional translator. The eye was optimally refracted for the 10' test distance (i.e., eyes are close to, if not, diffraction limited when optimally corrected and viewing through a 3 mm pupil diameter). Aberrated acuity charts were read until 5 letters were missed. We recorded total letters correct up to the 5th miss. Data was normalized for each subject to the acuity obtained by reading an unaberrated chart and plotted as letters lost as a function of Zernike mode. Results: Defocus (Z02) decreased letter acuity more than astigmatism (Z22 , Z-22). Coma (Z13 , Z-13) decreased acuity more then trefoil (Z33 , Z-33). Spherical aberration (Z04) and secondary astigmatism (Z24 , Z-24) decreased acuity much more than quadrafoil (Z44 , Z-44). Conclusion: 1) Not all modes of the Zernike polynomial induce equivalent losses in visual function for a fixed level of RMS error. 2) Large aberration-induced changes in chart appearance were not reflected in equally large decreases in visual acuity. This finding is consistent with the common patient complaint: "I can read the chart but it does not look as good as it used to.".

3/7/5 (Item 4 from file: 5)
DIALOG(R)File 5:Biosis Previews(R)

14160373 BIOSIS NO.: 200300154402
Visual Impact as a Function of Zernike Mode and RMS Error.
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JOURNAL: ARVO Annual Meeting Abstract Search and Program Planner 2002p Abstract No 2032 **2002**
MEDIUM: cd-rom
CONFERENCE/MEETING: Annual Meeting of the Association For Research in Vision and Ophthalmology Fort Lauderdale, Florida, USA May 05-10, 2002
RECORD TYPE: Abstract
LANGUAGE: English
ABSTRACT: Background:Normalized Zernike coefficients reveal the relative contributions of each Zernike mode to the total wavefront error (WFE). It is unknown how visual acuity varies with the magnitude of RMS error in each Zernike mode. Purpose: To determine the relative impact on high and low contrast log MAR acuity of individual Zernike modes (3 through 14) as a function of the magnitude of the RMS error. Methods: 3 healthy volunteers with 20/16 or better acuity served as subjects. CTViewTM (Sarver and Associates, Inc.) was used to generate high resolution simulated retinal images of high and low contrast log MAR charts at different RMS error levels (0.0, 0.05, 0.10, 0.15, 0.20, and 0.25mu over a 6mm pupil) for Zernike coefficients 3 - 14 projected into object space at 10 ft. RMS converted to equivalent defocus - ranged from 0.00 to 0.19 diopters. Subjects were dilated with 1% cyclopentolate hydrochloride. The foveal achromatic axis of the eye was aligned to a 3 mm pupil using an achromatic alignicator and a bite bar mounted to a 3 dimensional translator, and optimally refracted for the 10' test distance (i.e., eyes are close to if not diffraction limited at a 3 mm pupil diameter). Aberrated acuity charts were read until 5 letters were missed. Data was normalized to the acuity obtained by reading unaberrated charts and plotted as letters lost as function of RMS error. Results: Increasing aberrations, regardless of Z-mode decreased the mean acuity in a linear fashion. Letters lost/0.1 micrometers RMS error (Slope/10) for Zernike modes ordered from least (-0.9) to greatest (-4.0) for high contrast acuity are: Z10, Z6, Z11, Z9, Z14, Z7, Z12, Z3, Z5, Z8, Z13, Z4. For low contrast acuity (least -1.6, greatest -5.2): Z5, Z3, Z9, Z6, Z14, Z10, Z11, Z13, Z7, Z8, Z12, Z4. Conclusion: (1) The decrease in visual performance with increasing RMS error is well described by a linear function. (2) The slopes of the linear functions vary significantly with mode particularly for the high contrast charts. (3) The lower the absolute value of the angular frequency of the Zernike mode the larger the visual impact.

Visual Acuity Modeling Using Optical Raytracing of Schematic Eyes

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• PURPOSE: We developed a methodology to predict changes in visual performance that result from changes in the optical properties of the eye.
• METHODS: Exact raytracing of schematic eyes was used to calculate the point spread function and the modulation transfer function of the visual system. The Stiles-Crawford effect, photopic response, diffraction, and the retinal contrast sensitivity are included in the model. Visual acuity was predicted by examining the modulation of the resultant retinal image of a bar target and by determining when the modulation falls below a threshold value. Visual acuity was predicted for refractive errors ranging from 0 to 5 diopters and for pupil diameters ranging from 0.5 to 8 mm.
• RESULTS: Visual acuity predictions were compared to clinically found Snellen visual acuities and were found to be highly correlated ($r^2 = .909$).
• CONCLUSIONS: This modeling technique shows promise as a means of evaluating clinical and surgical procedures before undertaking clinical trials.

THE GOAL OF VISUAL MODELING IS TO PREDICT the visual performance or change in visual performance of an individual from a model of the human visual system. When modeling the visual system, it is convenient to consider at least two distinct functions in the eye. The first is the production of an image incident on the retina by the optical system of the eye. The second is the conversion of this real image into a perceived image by the retina and brain. Optical acuity can be defined as a measure of the quality of the image falling onto the retina, which is completely independent of the combined functions of the retina and brain. A variety of schematic eyes have been suggested to help model the function of the eye and, in some cases, to predict optical acuity.[1-9]

Schematic eyes are simplified representations of the optical system of the eye. They have evolved from models that predict the first-order properties of biologic eyes to models that include proper aberration content or match clinically found retinal illumination. As these additional factors are included, the complexity of the model increases. Because early eye models were evaluated by hand, simpler models were adequate. High-speed computers and sophisticated software packages can now easily and quickly handle many of the complexities of more recent eye models.

Some of the earliest eye models were introduced by Gullstrand[1] and von Helmholtz.[2] These models are a series of spherical surfaces that predict the first-order properties of the eye. Gullstrand's eye model was designed to be anatomically accurate to the first order. The cornea in the model consisted of two surfaces whose spherical curvatures were obtained by studying a variety of biologic eyes. The crystalline lens is modeled as a lower index shell with a higher index core to approximate the gradient index structure of actual lenses. The drawback of this anatomically based model is that much calculation is necessary to raytrace the model. Von Helmholtz's model is simpler and assumes that the cornea is a single surface and that the lens has a uniform effective index. Le Grand and El Hage[3] similarly simplified Gullstrand's schematic eye by making the lens uniform index, but maintained the two-surface cornea. All three of these models are still relatively popular today for studying

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No reprints are available.

the first-order properties of the eye. They all, however, fail to predict the aberration content of biologic eyes. The spherical aberration of these models remains well undercorrected compared with experimental findings.[4] Lotmar[5] modified the Gullstrand-Le Grand eye model by introducing aspheric surfaces on the anterior surface of the cornea and posterior surface of the lens. The asphericity of the cornea was determined keratometrically, and the asphericity of the posterior lens surface was varied to match the measured spherical aberration. El Hage and Berny[6] produced a similar model, except that they varied the asphericity of both lens surfaces to match the measured spherical aberration. Navarro, Santamaría, and Bescós[4] introduced aspheric surfaces on the anterior and posterior surfaces of both the cornea and lens. The shapes of these surfaces were an average of clinical measurements, and the dispersions of the eye media were adjusted to give clinically measured amounts of longitudinal chromatic aberration. The Navarro model also includes the Stiles-Crawford effect in the analysis. The Kooijman[7] eye model also uses all aspheric surfaces but is based on matching measured retinal illumination patterns rather than aberration content.

Simplified schematic eyes, which are based on a corneal surface alone, have also been used to model visual performance. Camp and associates[8,9] reported a technique for predicting the optical image formed on the retina from the actual measured corneal shape of an eye. The corneal power as a function of position is measured using a commercially available corneal topographer. This corneal power map is then used as the single surface of the simplified eye model. The geometric point spread function is determined by using a paraxial ray trace. The point spread function is the image of a point of light formed by the optical system. A series of rays from an object point is traced through different locations on the cornea. With this first-order model, the amount of bending of the ray is determined by the radial position of the ray and the radial corneal power at the ray intersection. The refracted rays are then extended to the image plane with the requirement that the ray path is restricted to a plane containing the optical axis and the intersection point (a meridional plane). After tracing a sufficient number of rays, the point spread function is approximated by the ray density in the image plane. To visualize the effects of different corneal shapes, a convolution technique is used to predict the images of Snellen and variable contrast letters formed by the cornea (a perfect image of the target is blurred by the point spread function). Conditions such as keratoconus and the effects of surgical procedures, such as epikeratophakia for aphakia and radial keratotomy, have been evaluated with this method. The method shows that different types of corneal errors produce different and distinctive point spread functions, and the visual performance in the presence of such errors can be subjectively evaluated from the appearance of the Snellen letters. The model performs well for severely distorted corneal surfaces but has difficulties predicting visual performance in normal patients. The methodology outlined above can, with some refinement, be extended to include the effects of the entire visual system and not just the cornea.

All of these schematic eye models can be used to predict the optical acuity. However, to fully describe the performance of the human visual system, the combined functions of the retina and brain must also be taken into account. When the combined functions of the retina and brain are included in modeling the human visual system, the concept of optical acuity must be extended to visual acuity. Visual acuity is related to the angular size of the smallest high-contrast target an individual can recognize. It is a combination of the performance of the eye optics, retinal effects, and processing performed by the brain. Optical acuity can be inferred from the schematic eye models mentioned above. By combining the effects of the retina and brain with these models, prediction of the true visual performance can be obtained.

To build on the work of Camp and associates[8,9] to predict optical and visual acuity, it is important to understand the limitations of their paraxial model. The first limitation is that the model is first order. Under this assumption, a spherical refracting surface will have no aberrations: a point source would image to a perfect point image. Paraxial raytraces ignore the surface sag and only use the radial surface power at the ray intersection point. Exact raytracing uses Snell's law to determine the ray bending at a surface. The exact intersection point of the ray with the optical surface must be determined in three dimensions, and the surface slope or surface normal must be calculated from the actual corneal surface height. Rays are also allowed to refract out of a meridional

plane. A second limitation is that the paraxial method ignores the effects of diffraction from the pupil, which results in a point spread function with nonzero blur size even with no aberrations.[10] Diffraction is a fundamental limit on the size of the point spread function, and the effects of diffraction are most noticeable for small pupil sizes. A third limitation is the use of a simplified eye model, which removes the effects of the inherent aberrations of the eye. Camp and associates[5,9] were aware of these limitations, and the choices they made were based on the desire to reduce the computational complexity (or the computation time) of the modeling. Other effects that are not included in the raytracing method of Camp and associates are the Stiles-Crawford effect and the combined functions of the retina and brain.

In this study, we modeled and predicted visual acuity. The optical performance of a schematic eye is analyzed through the use of exact optical raytracing. The combined functions of the retina and brain are then applied to the raytrace results to make a nonsubjective visual acuity prediction. To evaluate the performance of this visual system model, visual acuity was predicted for a variety of refractive power errors and pupil sizes. The results are compared with clinical data, and a high degree of correlation is found. Finally, the limitations and possible uses of these methods are discussed.

MATERIAL AND METHODS

IN THIS STUDY, WE ATTEMPTED TO OVERCOME THE limitations of the paraxial model of Camp and associates.[5,9] We first modeled optical acuity and later extended the analysis to predict visual acuity. The modeling was based on exact raytracing and included diffraction, the Stiles-Crawford effect, and the combined functions of the retina and brain. A schematic eye with aspheric surfaces was used. We somewhat arbitrarily chose the Kooijman[7] eye model as the starting point.

Exact raytrace programs have been developed by the optical industry to aid in the design and development of optical systems. In these programs, an optical system is represented by a series of surfaces, each with a curvature and possible asphericity, spacings, and indices. From this information and a user-defined pupil size, the programs can perform an exact raytrace. The set of raytrace data can then be used to evaluate the performance of the optical system. Some of the analyses used to evaluate performance include diffraction-based point spread functions and modulation transfer functions. These point spread functions and modulation transfer functions contain much detailed information about the performance of an optical system but do not relate to the clinical measurement of visual performance in an easy or obvious fashion. A patient's subjective evaluation of his or her visual performance is based on how well he or she sees details in the image of some test target. These images are more easily and quickly interpreted than abstract mathematical functions, such as the point spread function or the modulation transfer function. If the point spread function or the modulation transfer function of the system is known, the resulting image can be calculated. Methods for obtaining the point spread function and the modulation transfer function from the exact raytrace data and their associated properties will be briefly introduced in this section. Additionally, methods for obtaining degraded images of an arbitrary object from these functions will also be considered. This material is intended as an introduction; a more thorough description can be found in the texts by Smith[10] and Goodman.[11]

Calculation of the point spread function and modulation transfer function from exact raytracing—Exact raytracing is performed by propagating rays from a given object point through a set of locations in the entrance pupil of the optical system. Each ray is extended until it intercepts the next refracting surface. Once the intersection point between the ray and the surface is found, the angle between the ray and the local surface normal is calculated. The ray is refracted using Snell's law, and the ray is propagated to the next surface. The entire process is repeated until the ray reaches the image plane. In a perfect optical system, a point would be imaged to a point; a set of rays traced through the optical system would all intersect at a single image point. In an aberrated system, the rays from different locations in the pupil intersect the image plane at different locations resulting in a blur.

A related method for analyzing optical systems uses

wavefronts. The wavefront is always perpendicular to the rays. For an aberration-free optical system, the wavefront leaving the exit pupil is perfectly spherical and converges to a point in the image plane. With aberrations, the wavefront leaving the pupil is not spherical, since the rays do not converge to a single point. The wavefront produced by an optical system is determined from the exact raytrace by calculating the optical path (product of index of refraction and distance) along each ray. The difference in these paths from ray to ray in the exit pupil is the wavefront error function. The effects of diffraction caused by the finite extent of the pupil can also be included in this wavefront picture. Both the point spread function and the modulation transfer function of the system can be calculated from a complex function whose modulus is the transmission of the pupil and whose phase is the wavefront error function. This complex function is known as the pupil function.[11]

The point spread function, also known as the impulse response, is the intensity distribution of the image of a point source.[12] It can be calculated from the scaled square modulus of the Fourier transform of the pupil function. Since diffraction is present in any real optical system, the point spread function has a minimum blur size inversely proportional to the pupil diameter. Aberrations introduced by the optical system will further blur the point image. Over a small field of view, the point spread function does not change significantly in functional form. According to this assumption, the blurred optical image is obtained by convolving the point spread function with the object. The object is modeled as an array of incoherent point sources. The effect of the convolution is to blur each point in the object by the point spread function weighted by the local object intensity. For a given object point, the corresponding image intensity will be the sum of the point spread function at that point and the contributions from the tails of the point spread functions from other points in the vicinity. The size or width of the overlapping point spread functions determines the amount of image blur. This point spread function width can be used as a measure of the performance of an optical system.

The optical transfer function of the optical system is the Fourier transform of the system point spread function and is in general a complex-valued function. The modulation transfer function is given by the modulus of this function; however, 180-degree phase shifts are often indicated in modulation transfer function plots by allowing the modulation transfer function to take on negative values. This modification is done because rotationally symmetric systems are limited to phase shifts of 0 and 180 degrees. The modulation transfer function at a particular spatial frequency measures the reduction in modulation between a sine-wave object and its image. The modulation transfer function is usually normalized to unity at zero spatial frequency and is plotted as a function of spatial frequency (of the sine wave in either object or image space). It can also be calculated directly as a scaled autocorrelation of the pupil function. The effect of the finite pupil size is to limit the maximum spatial frequency that can pass through the optical system, and this frequency is known as the cutoff frequency.[11] The modulation transfer function will be zero for all frequencies above the cutoff frequency. By using modulation transfer functions, the image of a given object through the optical system is calculated by multiplying the object spectrum by the system modulation transfer function to get the image spectrum. The blurred image is then the inverse Fourier transform of this result. This is analogous to a Fourier decomposition of the object into a set of sinusoidal patterns, each of which is reduced in modulation by the modulation transfer function.

Image formation on the retina—If the point spread function or modulation transfer function of an optical system is known, the illumination pattern in the image plane corresponding to an object can be determined. The various calculation paths and interrelationships previously described are shown in Figure 1. The goal is to predict the image from an object by using the point spread function or the modulation transfer function. Either path produces the same result, and both methods will be used in the following sections to predict visual performance.

To predict optical acuity, the point spread function or modulation transfer function of a schematic eye is needed. The surface shapes, thicknesses, and indices of the Kooijman[7] schematic eye were used to perform an exact raytrace. The point spread function or the modulation transfer function was then obtained from

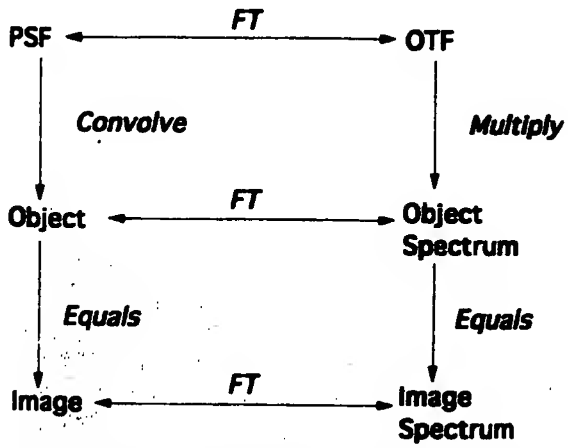

Fig. 1 (Greivenkamp and associates). Calculation methods for obtaining the image of a given object from either the point spread function (PSF) or the optical transfer function (OTF). One method is to convolve the point spread function with the object to obtain the image (left-hand column). An alternative method is to Fourier transform (FT) the point spread function and the object to obtain the optical transfer function and the object spectrum, respectively. The product of the optical transfer function and the object spectrum gives the image spectrum (right-hand column). The image is obtained by an inverse Fourier transform of the image spectrum.

the set of raytrace data. For the present analysis, Code V lens design software (Optical Research Associates, Pasadena, California) was used, although other programs have similar capabilities. As described henceforth, the Stiles-Crawford effect and the photopic response of the eye were also included in this analysis.

The Kooijman eye model used in this study is diagrammed in Figure 2, and its specifications are

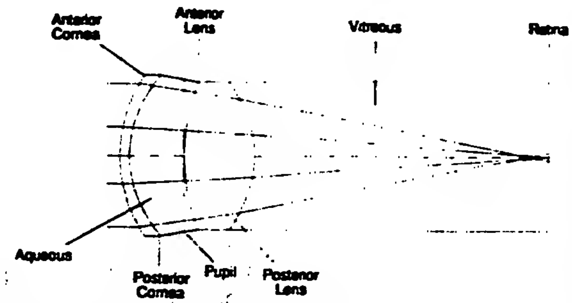

Fig. 2 (Greivenkamp and associates). The Kooijman[7] schematic eye.

given in the Table. The Table gives the radius of curvature, R, and the conic constant, K, for each of the aspheric surfaces. The surfaces can be generated in Cartesian coordinates by using the equation:

$$(1)\ z = \frac{(x^2 + y^2)\left(\frac{1}{R}\right)}{1 + \sqrt{1 - (K + 1)(x^2 + y^2)\left(\frac{1}{R}\right)^2}},$$

where x and y are the Cartesian coordinates, and z is the surface sag.[12] The thickness values refer to the vertex spacing following the surface. The indices are for the F, d, and C spectral lines and are for the medium corresponding to the spacing. Since the Kooijman model is specified only for a single wavelength, the indices for the F and C lines are taken from the eye model of Navarro, Santamaría, and Bescós.[4] (Note that there are several typographical errors in that paper. In the Hertzberger formula, the coefficients should read $a1(\lambda) = 0.66147196 - 0.40352796\,\lambda^2 - \ldots$ and $a4(\lambda) = -1.75835059 + \ldots$ The refractive index of the cornea should be 1.376.). The pupil is located at the anterior lens surface.

TABLE

SPECIFICATIONS OF THE KOOIJMAN SCHEMATIC EYE

SURFACE	ANTERIOR CORNEA	POSTERIOR CORNEA	ANTERIOR LENS	POSTERIOR LENS
Radius of curvature, R (mm)	7.8	8.5	10.2	−6.0
Conic constant, K	−0.25	−0.25	−3.06	−1.0
Shape	Ellipsoid	Ellipsoid	Hyperboloid	Paraboloid
Thickness (mm)	0.55	3.05	4.0	16.6
Index λ = 486.1 nm (F)	1.3807	1.3422	1.42625	1.3407
Index λ = 587.6 nm (d)	1.3771	1.3374	1.42	1.336
Index λ = 656.3 nm (C)	1.37405	1.3354	1.4175	1.3341

While the fovea is located several degrees from the optical axis of the eye model, visual performance is evaluated along the optical axis for simplicity and to maintain rotational symmetry. This restriction can be removed if desired. The curvature of the retina is not important for this analysis because the performance of the model is evaluated only over a small field of view.

The Stiles-Crawford effect is easily added to the raytrace model. The Stiles-Crawford effect relates a reduction in the perceived visual response as a function of increasing angles of incidence of light on the retina.[13] The Stiles-Crawford effect is included in the raytrace eye model by placing an apodizing filter in the entrance pupil of the system. An apodizing filter has a spatially varying optical transmission; in this case, the central portion of the filter will have a higher transmission than the edges.[15] As the radial distance of the ray from the optical axis in the pupil increases, the angle of incidence of the ray onto the retina also increases. The filter provides the appropriate weighting to each ray based on its position in the pupil and therefore its angle of incidence at the retina. Rays farther from the optical axis in the pupil are weighted less than axial rays, to simulate the Stiles-Crawford effect. The apodizing filter provides a gaussian falloff in transmission through the entrance pupil. The transmission, T, as a function position in the entrance pupil of such a filter, is described by van Meeteren[14] and is given by the equation:

$$(2)\ T(\rho) = e^{[illegible]},$$

where ρ is the radial pupil coordinate, and $\alpha = 0.108$. The intensity transmission is unity at the center of the pupil and falls of to 0.42 at a pupil radius of 4 mm.

Even though the Stiles-Crawford effect is primarily a retinal effect, it is easy and best to model it as part of the optical system. The inclusion of the Stiles-Crawford effect in the modeling is important. For rays going through the edge of the pupil, more aberrations are introduced. By providing a lower weighting for these more eccentric rays, the Stiles-Crawford effect helps to reduce these aberrations and improve the perceived image quality. Since the Stiles-Crawford effect can markedly improve visual performance, it should be included in the model to ensure prediction accuracy. It is important to note that the modeling will now differ (at least in order) from the actual physical process occurring in the eye. As quantities such as the point spread function are computed, the modeling will not predict the optical illumination pattern on the retina, but rather a Stiles-Crawford-weighted point spread function. The same holds for other quantities.

Three wavelengths are used in the modeling. These wavelengths (λ) are 486.1, 587.6, and 656.3 nm, which correspond to the F, d, and C spectral lines, respectively, and spa[illegible] [illegible] the approximate range of the visible spectrum. To approximate the photopic response of the eye, the central wavelength is weighted three times more heavily than the other wavelengths.

All the factors described above are entered into the lens design software, a pupil size is defined, and a set of rays is traced through the model. As described above, the diffraction point spread function or diffraction modulation transfer function is calculated. If the point spread function is generated, the optical image falling on the retina (weighted by the Stiles-Crawford effect) is obtained by convolving this optical point spread function with the scene or object (Fig. 1). The optical acuity can be observed by using an object that is a set of letters corresponding to the letter sizes on a Snellen chart.[illegible] For a given point spread function, the images of the letters will become increasingly difficult to read as they get smaller. The size at which the letter is no longer identifiable corresponds to the optical acuity. For illustration, Figure 3 shows the resultant image of a series of Snellen Es when they are convolved with a gaussian point spread function.

While the convolution method of determining a resultant retinal image is easy to visualize, it is computationally slow. The identical result can be obtained much faster by using Fourier theory and the speed of the fast Fourier transform. Fast Fourier transforms are computer algorithms for performing discrete Fourier transforms. The algorithms have been optimized for computational speed and are much faster than any convolution algorithm. As stated earlier, the Fourier transform of the point spread function gives the modulation transfer function of the optical system. An image can be obtained by first multiplying the modulation transfer function by the spectrum of an object and then inverse Fourier transforming the product. This is the alternate path shown in Figure 1. The resulting blurred image is the

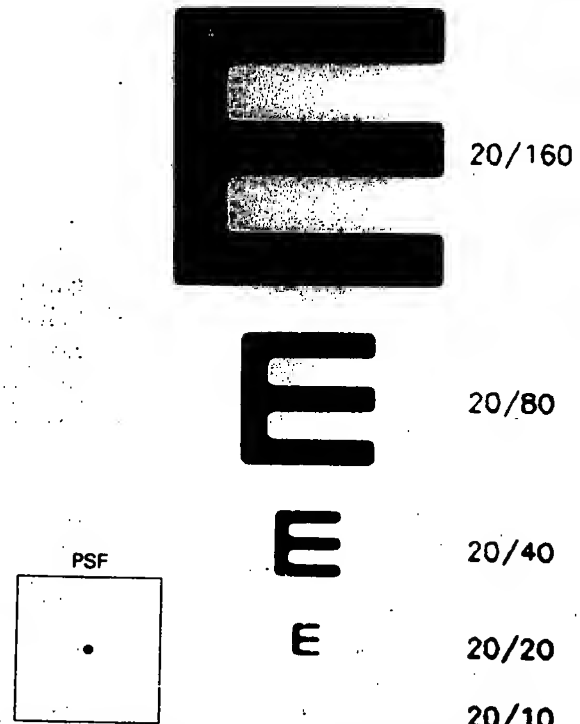

Fig. 3 (Greivenkamp and associates). Convolution of various sized Snellen Es with a gaussian point spread function. The relative Snellen acuity is shown to the right of each Snellen E. The point spread function is shown to scale in the lower left-hand corner.

same as the image obtained using the convolution technique.

The model has been used to calculate the point spread function and the modulation transfer function of the model eye as a function of refractive error and pupil diameter. To simulate a refractive error, a spectacle lens is placed at the front focal point of the eye model. The power of the spectacle lens is varied to introduce the desired amount of refractive error. To ensure that additional chromatic aberration is not introduced into the model, a dispersionless lens is used. Figure 4 shows the resulting point spread functions obtained for a 4-mm pupil with two different levels of refractive error.

The modulation transfer functions corresponding to these point spread functions were then used to blur a Snellen visual acuity chart as previously described. However, instead of displaying the E with decreasing size, we have found it easier to display each E at the same size and to vary the scale factor of the point spread function. The Snellen Es are kept a constant size (80 × 80 pixels, corresponding to 16 samples across each black bar or white space), and the size of the point spread function is changed to examine different visual acuity levels. The advantage of varying the point spread function scale instead of the Snellen letter size is that the number of samples displayed for each E remains constant. The display resolution does not become a factor in examining the degree of blur. Because this method is used, the blurred images all appear the same size, and only the scales will change between successive acuity levels. The left side of Figure 5 shows the convolution of a series of Snellen Es, with a point spread function generated from the eye model by using a 4-mm pupil and a 0.5-diopter refractive error.

To predict optical acuity, the quality of the blurred images needs to be evaluated. Image quality is, however, ambiguously defined and highly subjective. Examining the blurred images formed by the methods previously described underestimates visual performance. The visual acuities predicted subjectively from the smallest identifiable E are worse than the visual acuities found clinically for the same refractive errors and pupil sizes. To predict visual performance accurately, a more objective analysis of the image quality is needed.

Visual acuity prediction—An objective procedure for determining image quality and predicting visual acuity can be based on the modulation in the resulting image. Modulation is a well-defined quantity that is a direct measure of image quality. The right side of Figure 5 shows the intensity profiles along a vertical slice through the three bars of the Snellen E images in the left side of Figure 5. The modulation M of the image is determined from these profiles by the equation:

$$(3)\ M = \frac{I_{MAX} - I_{MIN}}{I_{MAX} + I_{MIN}},$$

where I_{MAX} is the maximum image intensity, and I_{MIN} is the minimum image intensity.[10] Because each E is a different size, the bars of each E correspond to different spatial frequencies. Figure 6 illustrates the method of determining the modulation of a sinusoidal pattern.

Fig. 4 (Greivenkamp and associates). Left, The point spread function for a 0.5-diopter refractive error and a 4-mm pupil diameter. Right, The point spread function for a 1.0-diopter refractive error and a 4-mm pupil diameter. The full dimension of each plot is 0.252 × 0.252 mm.

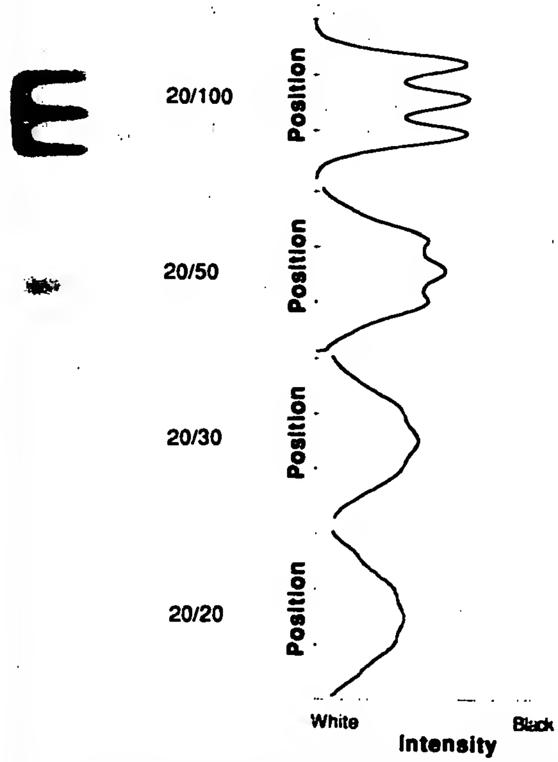

Fig. 5 (Greivenkamp and associates). Left, The image of several Snellen Es for the eye model with a 4-mm pupil and 0.5-diopter refractive error. The relative Snellen acuity is seen to the right of each blurred image. Right, A vertical intensity profile through the Snellen E to display the modulation present in the resultant images.

To accurately predict visual performance from the image modulation, the combined functions of the retina and brain must be included in the model. An available measure that fits into this framework is the contrast sensitivity function. This function describes the minimum image modulation required for a specific spatial frequency to be detected. There are several reported measures of the retinal contrast sensitivity,

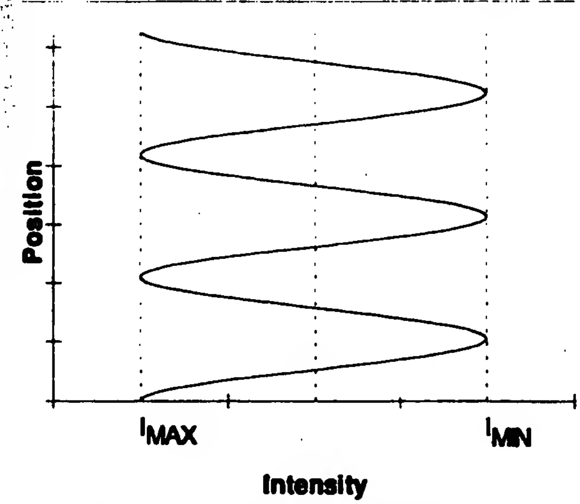

Fig. 6 (Greivenkamp and associates). A simulated intensity profile through a blurred image of a Snellen E. The brightest intensity (I_{MAX}) and the darkest intensity (I_{MIN}) are used to calculate the modulation in the blurred image.

and for this modeling, the results of Campbell and Green[15] were used. They measured the retinal contrast sensitivity function by imaging two coherent point sources near the front nodal point of the eye. Light from the two sources interferes to form a sinusoidal pattern on the retina.[16] In this arrangement, the effects of diffraction, refractive error, and aberration on the modulation and frequency of the sinusoidal pattern are negligible. The modulation of the sinusoidal pattern is varied by adding uniform-intensity incoherent illumination to the pattern on the retina. Its frequency is varied by changing the point spacing. By finding the minimum detectable modulation for various spatial frequencies, the retinal contrast sensitivity function is calculated. The retinal contrast sensitivity is the reciprocal of the minimum image contrast required on the retina to observe a particular spatial frequency. The minimum image contrast requirement is called the modulation threshold. Figure 7 shows the modulation threshold adapted from the results of Campbell and Green.[15] Because of the method of measurement, the Stiles-Crawford effect does not influence the modulation threshold, showing the need to include this effect in the eye model.

The clinical measurement of visual acuity uses some form of eye chart, such as a Snellen chart. A Snellen chart consists of a series of letters that decrease in size from line to line. When an observer views the chart, the smaller letters on the chart will be blurred the most or, equivalently, will show the greatest reduction in image modulation. The letters for which the modulation is below the threshold of

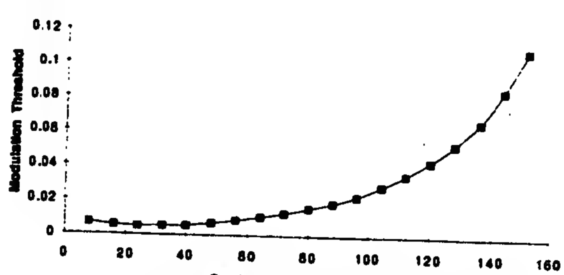

Fig. 7 (Greivenkamp and associates). Modulation threshold function of Campbell and Green.[15]

the spatial frequency corresponding to that letter will not be resolved. The letter size for which the image modulation equals the threshold is an estimate of the visual acuity of the system. This modeling method for predicting visual acuity is an attempt to be completely analogous to clinical methods for a given pupil size and dioptric blur. The modulation of a blurred E computed by the raytrace model is compared with the modulation threshold of the retina, and the size of the E is varied until its image modulation equals the threshold as measured by Campbell and Green.[15] The spatial frequency of this E is related to a certain line on the Snellen eye chart and corresponds to a visual acuity. This prediction method includes the optical aberrations of the eye, diffraction, the retinal contrast sensitivity, and the Stiles-Crawford effect.

This method is simple for conceptual purposes but proves exceedingly tedious in practice. The same results once again are more easily and quickly obtained by returning to the spatial frequency domain. If the modulation threshold is plotted on the same graph as the modeled modulation transfer function, the spatial frequency where the modulation transfer function equals the modulation threshold is the maximum sinusoidal spatial frequency that can be detected by an individual. However, the test charts used to measure visual acuity use binary (that is, black and white) targets. It is easy to visualize the bars of a Snellen E as a bar target. To account for this difference in predicting visual acuity, a close relative of the modulation transfer function, the square-wave modulation transfer function,[10] can be used. The modulation transfer function describes the attenuation of a sinusoidal pattern imaged through an optical system. Similarly, the square-wave modulation transfer function describes the attenuation of a bar target imaged through an optical system. The square-wave modulation transfer function is obtained from the modulation transfer function by Fourier decomposing the bar target. A bar target is made up of a fundamental sinusoidal frequency along with various amounts of higher-order odd harmonics. Each of these harmonics along with the fundamental frequency is attenuated as it passes through the optical system. The amount of attenuation of each individual spatial frequency component of the bar pattern is deter-

mined by the modulation transfer function. The reassembled frequencies form the image of the bar target, and the net modulation of the image is the square wave response at a given frequency. Mathematically, the square-wave modulation transfer function is given by the equation:

$$(4)\ \mathrm{SMTF}(\xi) = \frac{4}{\pi}\left[\mathrm{MTF}(\xi) - \frac{\mathrm{MTF}(3\xi)}{3} + \frac{\mathrm{MTF}(5\xi)}{5} - \frac{\mathrm{MTF}(7\xi)}{7} + \ldots\right],$$

where ξ is spatial frequency, MTF is the modulation transfer function, and SMTF is the square-wave modulation transfer function. The square-wave modulation transfer function is readily available as a standard output from the raytrace code. The bars of a Snellen E can be considered to be a truncated bar target. Since visual acuity is normally measured using Snellen letters or some equivalent, matching the modulation threshold with the square-wave modulation transfer function is the appropriate choice for determining visual acuity. Figure 8 shows the square-wave modulation transfer function for the Kooijman eye model with a 2-mm pupil and a plot of the modulation threshold. The spatial frequency where the curves intersect is an estimate of the visual acuity.

Visual acuity is usually not given in terms of spatial frequency. A Snellen E is 2.5 cycles in the vertical direction and for a given line on the eye chart, the E has a certain height on the retina. If 2.5 cycles is divided by this height, the spatial frequency corresponding to the line on the eye chart (or visual acuity) is obtained. The conversion of spatial frequency to Snellen distance is given by the equation:

$$(5)\ \text{Snellen Distance} = \frac{2{,}000}{\xi},$$

where ξ is the spatial frequency, in cycles per millimeter, on the retina.[17] For example, in Figure 8 the intersection point of the square-wave modulation transfer function and the modulation threshold occurs at $\xi = 155$ cycles/mm. The equivalent Snellen distance is 13, or the visual acuity is 20/13.

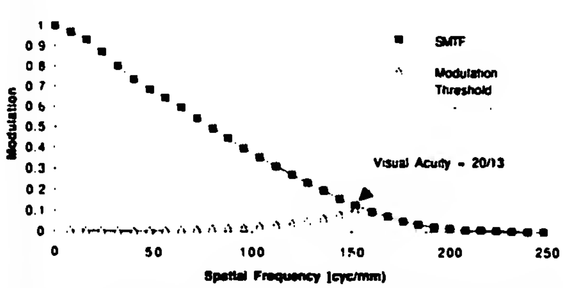

Fig. 8 (Greivenkamp and associates). Determination of visual acuity from the square-wave modulation transfer function (SMTF). The intersection of the square-wave modulation transfer function and the modulation threshold at 153 cyc/mm determines the spatial frequency of a barely resolvable bar target. This spatial frequency can be converted to an angular subtense or a Snellen distance.

RESULTS

THE CLINICAL DATA USED TO TEST THE VALIDITY OF THIS method of visual acuity prediction are those of Holladay and associates.[18] They provide a literature summary of the clinical relationship between Snellen acuity, best-corrected refractive error, and pupil diameter. The summary results are shown in Figure 9. These results combine 12 studies, each with ten to 10,000 patients. The results of this survey are intuitively pleasing. They show that, for small pupil sizes, diffraction is the primary limitation in visual acuity and that refractive error is not appreciable. As the pupil diameter increases to 3 to 4 mm, visual acuity also improves; here diffraction only slightly degrades

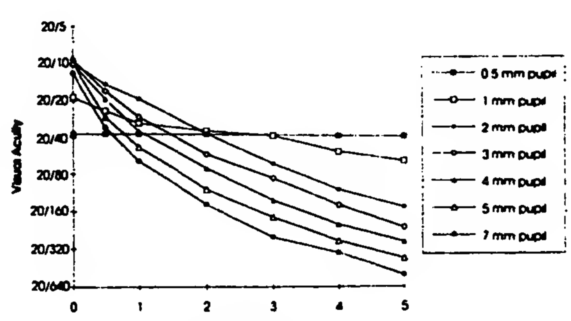

Fig. 9 (Greivenkamp and associates). Visual acuity vs refractive error in diopters (D) and pupil diameter. Each visual acuity value is from a summary of clinical results compiled by Holladay and associates.[18]

the image while aberrations are still minimal. Increasing the pupil diameter further causes a falloff in visual acuity as aberrations begin to markedly affect image quality. Increasing power error steadily diminishes acuity for these final two cases. Since the Holladay results are so well behaved and are an average of thousands of patients, they are taken as accurate predictions of visual acuity for individuals with normal retinal contrast sensitivities.

For each power error (0, 0.5, 1, 2, 3, 4, and 5 diopters) and pupil size (0.5, 1, 2, 3, 4, 5, 6, 7, and 8 mm) presented in the clinical summary, the corresponding schematic eye was modeled. Only myopic refractive errors were examined. The entrance pupil was set to the desired diameter, and the power of the spectacle lens placed at the front focal point of the eye was varied to introduce the appropriate amount of refractive error. From the resulting raytrace, the square-wave response was generated for each of the 63 combinations of pupil size and power error, and the intersection of the square-wave modulation transfer function and the modulation threshold was found. The intersection was converted to a Snellen visual acuity. Figure 10 shows the results of the visual acuity predictions from the eye model.

By comparing Figure 10 directly to Figure 9, the model results followed the same general trend as the survey by Holladay and associates.[18] Figure 11 shows a plot of the visual acuity for the clinical data vs the modeling results. There was a strong linear correlation (r^2 = .909), and all the modeling predictions fell within one octave of acuity of the clinical results.

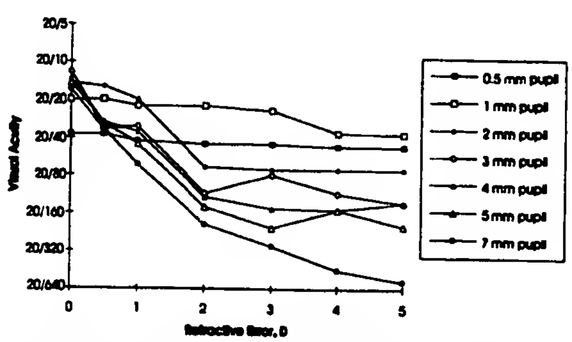

Fig. 10 (Greivenkamp and associates). Visual acuity vs refractive error in diopters (D) and pupil diameter. Each visual acuity value is predicted from the eye model.

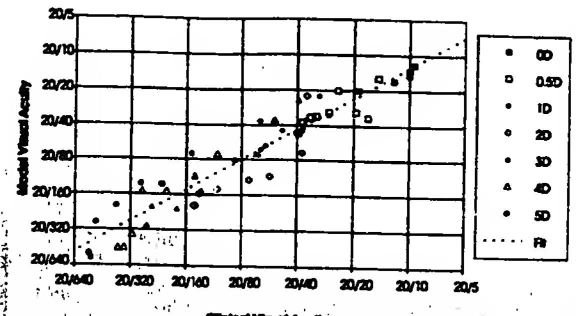

Fig. 11 (Greivenkamp and associates). Plot of the clinical visual acuity results vs the visual acuities predicted from the eye model. The refractive errors are measured in diopters (D) and range from 0 to 5 diopters. The dashed line represents a linear fit to the data, and the correlation coefficient, r^2, is 90.9%.

The diffraction-limited data points were calculated by finding the maximum spatial frequency that can pass through an ideal optical system. These data points were neither a consequence of the specific modeling techniques described above nor measured clinically in the studies compiled by Holladay and associates.[16] These data points were not included in the statistical analysis.

DISCUSSION

IN THIS STUDY, WE ATTEMPTED TO MODEL THE HUMAN visual system to predict visual performance. We used a modeling methodology that included as many clinically relevant properties as possible. These factors included the Stiles-Crawford effect, which reduces the influence of aberrations at large pupil sizes; the photopic response of the retina, which allows chromatic effects to be included; and the retinal contrast sensitivity function, which brings the retinal modulation threshold into the analysis. Most of these features were not addressed in earlier modeling studies. Starting with a schematic eye and an exact raytracing capability, we showed how to include these features in a straightforward manner by using commercially available optical design software. Although a number of specific functional forms have been somewhat arbitrarily assumed in this study (for example, schematic eye design, contrast sensitivity function, and the like), the methodology remains general. A differ-

ent eye model or response function can be easily substituted in the methodology.

The analysis quantitatively predicts visual performance rather than subjectively evaluates blurred images of Snellen charts (which tends to predict worse visual acuity). By including the combined functions of the retina and brain response, a more accurate prediction of visual acuity was obtained. Although important differences between our modeling results and the corresponding clinical data exist, the model does show a performance falloff with changes in refractive error and pupil size that is consistent with the clinical data. The modeling method should therefore be very useful for examining changes in visual acuity when small perturbations are applied to the model. Additionally, changes in the overall visual contrast sensitivity function can be predicted by looking at the Stiles-Crawford weighted modulation transfer functions before and after a perturbation to the eye model.

Although the model is relatively simple to implement, care must be taken when calculating the pupil function. In the presence of large amounts of aberration or refractive error, the wavefront leaving the exit pupil deviates markedly from a sphere. Only a finite number of rays are used to raytrace the optical system, and the wavefront error function is evaluated in the pupil only along these rays. If the sample density in the wavefront error array is insufficient to represent the wavefront error function, then there will be appreciable error in the point spread function or the modulation transfer function. For the point spread function or modulation transfer function to be calculated accurately, the wavefront error between adjacent points in the array must be less than one half the wavelength of light. If this condition is not met, aliasing occurs in the fast Fourier transform algorithm.[14] For the most severe cases of refractive error and pupil sizes examined in this study, the number of samples needed across the diameter of the exit pupil is several thousand. The large number of samples produces some difficulties because of long computation times and the amount of computer memory required. Work is underway to refine the modeling of the wavefront error function to ensure calculation accuracy.

A major limitation to the modeling of visual performance occurs in the presence of large amounts of aberration or refractive error. In this situation, the square-wave modulation transfer function tends to oscillate, resulting in multiple spatial frequencies where the response drops to zero. This condition can result in a contrast reversal of the image. Contrast reversal, or spurious resolution, is known to be a common consequence in defocused systems.[11] The square-wave modulation transfer function with multiple zeroes can drop below the retinal modulation threshold only to exceed the required modulation at a higher spatial frequency. This ambiguity in the threshold spatial frequency can repeat several times, resulting in several possible values for the predicted visual acuity. When this situation was encountered in this study, the frequency at which the square-wave modulation transfer function drops below the modulation threshold for the second time was chosen to represent the resolution limit. This choice permits a single contrast reversal and ignores additional reversals. Better methods for accurately determining the resolution limit in these cases are also being investigated.

The prediction accuracy of the model may be improved by obtaining response functions that are more clinically representative than those used. The retinal contrast sensitivity function of Campbell and Green[15] was assumed. The Campbell and Green data, however, are based on the measurement of a single individual at a single wavelength. Retinal contrast sensitivity varies significantly from person to person, so a contrast sensitivity norm may be needed instead. The functional form of the Stiles-Crawford attenuation may also need to be altered. The modeling of chromatic effects by evaluating the system at only three specific wavelengths may be insufficient for accurate analysis.

There may also be important ramifications resulting from the choice of the schematic eye on the performance of the model. The Kooijman[7] eye model was designed to give the clinically found retinal illumination, but its aberration content may not sufficiently match clinical measurements. Although matching all the anatomic properties of the human eye is desirable, the important goal for the schematic eye used for the modeling is that its performance matches the performance of the human eye. The least complex model that meets this requirement will minimize the computational complexity. The indices

of the aqueous, vitreous, and cornea are generally accepted as accurate representations of normal biologic eyes. The external corneal shape can be measured keratometrically. The useful parameters that remain are the shapes of the lens surfaces and the dispersion of the eye media (especially the lens).

A basic assumption of this study in predicting visual acuity is that the detection of modulation of a letter is equivalent to the recognition of that letter. This assumption may be accurate for letters such as E, when viewing conditions are great, but may be highly inaccurate for other letters or when contrast reversals exist. More sophisticated methods of determining the point on the square-wave modulation transfer function that corresponds to the visual acuity may be needed. Additionally, only rotationally symmetric optical systems have been considered to date. When errors such as astigmatism are present in the eye, the square-wave modulation transfer function curve will change with orientation. A decision process that allows a single visual acuity number to be generated must be found.

This modeling method can be used to determine the effects of clinical and surgical techniques on visual performance. Contact lens or intraocular lens performance can be evaluated, and the effects of tilt and decentration of these elements on visual acuity, modulation transfer function, or contrast sensitivity can be studied. It should be possible to model surgical procedures such as radial keratotomy and photorefractive keratectomy by altering the shape of the model cornea, raytracing the system, and examining the change that occurs in the modulation transfer function or the contrast sensitivity. The versatility and simplicity of the model are appealing. The use of modeling of this type should allow the determination of tolerances for some procedures before extensive clinical trials are undertaken.

An advantage to this type of modeling may be in the screening of new procedures. The model can be used before clinical studies, to predict the results expected from these new procedures and to eliminate studies that are not beneficial. Once a technique is verified through modeling, a clinical study can then be performed.

With some lens design software, it is possible to apply an arbitrary surface height map to any surface in the eye model. By taking advantage of this feature, corneal topography data can be incorporated into the modeling. Several commercial topographers output a surface height map of the topography data directly. By altering the corneal shape in the eye model to the surface described by these height data, clinically measured topography can be included in the visual modeling.

The modeling can also be used to predict visual performance on an individual basis. Currently, work is underway to measure corneal topography, axial length, best refraction, contrast sensitivity, and visual acuity of individuals. A customized eye model will then be constructed for that individual, and its performance and relevant anatomic features will be consistent with those of the patient. c The same prediction accuracy as the modeling above is anticipated. Modifications can then be made to this custom model to simulate the postoperative performance of the individual. e With this method, the effectiveness of the treatment can be evaluated ahead of time. The model potentially provides a quick and cost-effective evaluation of new and existing clinical and surgical techniques. f

This work is a preliminary attempt to provide a comprehensive analysis of the human visual system to predict visual performance. The Kooijman[7] eye model was chosen as a starting point for the modeling, and additional effects, such as the Stiles-Crawford effect, diffraction, and the photopic response of the eye, were included. Exact raytracing has been used to avoid limitations of paraxial raytracing and to ensure the accuracy of the calculated point spread functions and modulation transfer functions needed to make visual acuity prediction. The prediction of visual acuity from the optical performance of the eye model requires the inclusion of the retinal contrast sensitivity function. A simple retina and brain response model is used in this work so that the methodology is easily implemented. The model's usefulness appears to be in determining the changes in visual performance caused by changes in the optical system. The results of this model were verified against clinically found results, and a high correlation (r^2 = .909) was found. The results of the modeling are very encouraging but show the need for additional sophistication and new approaches. The primary limitation to our methods is the calculation of the square-wave response in the presence of large aberrations.

Although the inclusion of many of the practical properties of the human visual system may appear to result in a very complex model, it is relatively simple to implement with commercially available lens design software. This modeling technique shows promise as a nonsubjective method for determining visual acuity and a quick and inexpensive means of evaluating clinical and surgical procedures.

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